STEAMSHIPS AND THEIR STORY

THE WHITE STAR LINER "OLYMPIC"

(Drawn by Charles Dixon, R.I.)

BY

London, New York, Toronto and Melbourne
1919

STEAMSHIPS
AND THEIR STORY

BY

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Author of "Sailing Ships and Their Story"

WITH 153 ILLUSTRATIONS

CASSELL AND COMPANY, LTD.

London, New York, Toronto and Melbourne

1910

PREFACE

THE exceptionally kind reception on the part of both Press and public which greeted the appearance of my history of the sailing ship last year, and the numerous expressions of appreciation that have reached me from so many parts of the world, have encouraged me to attempt in a similar manner to set out the story of the steamship from the earliest times to the present day.

I am by no means unaware that between the sailing ship and the steamship there is a wide difference, as well in character as in their respective development. But that is no reason for supposing that the steamship is less interesting in her history or less deserving of admiration in her final presentation. Around the sailing ship there hovers eternally a halo of romance; that is undeniable even by the most modern enthusiast. But, on the other hand, the sailing ship in the whole of her career has not done more for the good of humanity than the steamship within a century or less. It requires but a moment of thought to realise the truth of this statement; and for that reason alone, the history of the steamship makes its appeal not to a special class of reader, but to all who interest themselves in progress, in the development of their own country and empire, in the welfare of the world generally, and the evolution from stagnation to beneficial activity and prosperity. There are but few civilised people nowadays who have not been brought into contact with the steamship in one way or another. Perhaps sometimes it has been unwillingly, though

at other times to their great gain. In some of those moments which have seemed to drag on wearily during the enforced idleness of a voyage, the inquiring mind has over and over again exhibited a desire to know something of the nature of the fine creature which is carrying him from one distant country to another. He has desired to know in plain, non-technical language, how the steamship idea began; how it developed; how its progress was modified, and what were the influences at work that moulded its character as we know it to-day. Further, he has felt the desire to show an intelligent interest in her various characteristics and to obtain a fair grasp of the principles which underlay the building and working of the steamship. As a normal being himself, with mind and sympathy, he has wished to be able to enter into the difficulties that have been overcome so splendidly by the skill and enterprise of others, both past and present. If he talks to the professional sailor or marine engineer, they may not, even if they have the inclination to unbend, be able easily to separate their explanation from the vesture of technicality, and the inquirer is scarcely less satisfied than before. It is, then, with a view of supplying this want that I have aimed to write such a book as will interest without, I trust, wearying, the general reader.

The plan on which I have worked has been to give the historical continuity of the steamship from the most reliable and authoritative material obtainable, and to supplement and correct a number of false statements by comparison with the latest researches. At the same time, my object has been not merely to ensure absolute historical accuracy, but to show how in a special manner and peculiar to itself the steamship is every bit as romantic, and equally deserving of our affectionate regard, as her predecessor the sailing ship, whose sphere

of utility she has succeeded so materially in limiting. After having been brought safe and sound through gales of wind, across many thousands of miles of ocean, past cruel coast, and through treacherous channels, until at last the fairway and the harbour of safety have been reached, no one who has any heart at all can step ashore without feeling that he is parting from one of the noblest and best friends that a man ever had. True, there are some people, as an officer on one of the crack liners once remarked to me, who, as soon as ever the big ship is tied up alongside the landing-stage, hurry ashore from her as if she were a plague-ship. But such, let us hope, are the few rather than representative of the majority who have been brought into intimate relationship with the steamship.

Nor only to the history and the glamour of the great steam-driven vessel have I confined myself. The sea is not merely a wide ocean, but contains within its mighty bosom many smaller areas such as channels and bays wherein the steamboat is able to ply as well for pleasure as for profit; and besides the big, brave sisters with their enormous displacement and their powerful engines, there are other children which run across smaller sea-ways, and these, too, are not to be passed over lightly. Then there are fleets of special steamships which in a quiet, unostentatious manner do their noble work, and are none the less efficient, even if they escape the limelight of general publicity. I shall seek to show in the following pages not merely the conditions which in the past have hindered or helped the ship-maker, but to indicate the modern problems which have still to be faced and overcome.

The difficulty that awaits an author who writes on a technical

subject for the benefit of the non-technical, average reader, is always to make himself intelligible without being allowed the full use of the customary but technical terms. In order that, as far as possible, the present volume may be both a full and accurate account of the steamship, in all times and in all the phases of her development, whilst yet being capable of appreciation by those to whom technicalities do not usually appeal, I have endeavoured whensoever possible to explain the terms employed.

The story of the steamship may at the first mention seem to be bereft of any interest beyond that which appeals to an expert in marine engineering. Pipes and boilers and engines, you are told, are not suggestive of romance. To this one might reply that neither were sails and spars during the first stages of their history; and I shall hope that after he has been so kind as to read the following pages, the reader may feel disposed to withdraw the suggestion that the steamship is a mere inanimate mass of metal. On the contrary, she is as nearly human as it is possible to made a steel shell, actuated by ingenious machinery; and, after all, it is the human mind and hand which have brought her into being, and under which she is kept continuously in control. It would be surprising, therefore, since she has been and continues to be related so closely to humanity, if she should not exhibit some of the characteristics which a human possesses.

It is fitting that the history of the steamship should be written at this time, for if final perfection has not yet arrived, it cannot be very far distant. It is but three or four years since the *Lusitania* and *Mauretania* came into being, and only during the present year have they shown themselves to possess such exceptional speed for merchant ships. On the 20th of

October, 1910, will be launched the *Olympic,* whose size will dominate even the *Mauretania.* Much further than a 45,000-ton ship, surely, it cannot be possible to go; and the likelihood is that with the commercial steamship's manifested ability to steam at the rate of over thirty-one land miles per hour, we are in sight of the limitations which encompass her. As to the future of transport, changes happen so quickly, and possess so revolutionary a character, that it is hardly safe to prophesy; but it is significant that the week before this preface was written, an aeroplane succeeded in flying, in perfect ease and safety, the 150 miles which separate Albany from New York; and thus, just a century after Fulton had convinced the incredulous by traversing the same course through water in his steamship, the latest means of travelling from one place to another has caused to look insignificant the wonderful record which Fulton, in his *Clermont,* was the first to set up. If, then, as will be seen from this volume, the steamship has done so much within a hundred years, what, we may legitimately ask, will be accomplished by the airship or aeroplane before another century has come to an end? Those who have the temerity to give expression to their opinions, suggest that the steamship will ultimately be made obsolete by the flying craft. If that be a true forecast, it is perhaps as well that the steamship's story should be told here and now whilst yet she is at her prime.

Of the matter contained within this volume, much has been obtained at first hand, but much has also been derived from the labours of others, and herewith I desire to acknowledge my indebtedness. I would especially wish to mention in this connection: "A Chronological History of the Origin and Development of Steam Navigation, 1543–1882," by Geo.

Henry Preble, Rear-Admiral U.S.N. (1883); certain articles in the "Dictionary of National Biography"; "Ancient and Modern Ships: Part II., The Era of Steam, Iron and Steel," by Sir George C. V. Holmes, K.C.V.O., C.B. (1906); "The Clyde Passenger Steamer: Its Rise and Progress," by Captain James Williamson (1904); "The History of American Steam Navigation," by John H. Morrison (1903); "The History of North Atlantic Steam Navigation," by Henry Fry (1896); "The American Merchant Marine," by W. L. Martin (1902); "The Atlantic Ferry: Its Ships, Men, and Working," by Arthur J. Maginnis (London, 1893); "Ocean Liners of the World," by W. Bellows (1896); "Life of Robert Napier," by James Napier (1904); "Handbook on Marine Engines and Boilers," by Sir G. C. V. Holmes (1889); "The Royal Yacht Squadron," by Montague Guest and W. B. Boulton (1903); "The Rise and Progress of Steam Navigation," by W. J. Millar (1881); "Practical Shipbuilding," by A. Campbell Holms; "The Boy's Book of Steamships," by J. R. Howden (1908); "The Steam Turbine," by R. M. Neilson (1903); "Our Ocean Railways, or Ocean Steam Navigation," by A. Macdonald (1893); "Life of R. Fulton and a History of Steam Navigation," by T. Wallace Knox (1887); "Life on the Mississippi," by Mark Twain; "American Notes," by Charles Dickens; "The Orient Line Guide," by W. J. Loftie (1901); "The History of the Holyhead Railway Boat Service," by Clement E. Stretton (1901); the "Catalogue of the Naval and Marine Engineering Collection in the Science Division of the Victoria and Albert Museum, South Kensington" (1899); "Catalogue of the Mechanical Engineering Collection in the Science Division" of the above (1907); "The Progress of German Shipbuilding" (1909); "Leibnizens und Huygens

Briefwechsel mit Papin," by G. W. Von Leibnitz (1881); "British Shipbuilding," by A. L. Ayre (1910); "Lloyd's Calendar." In addition to the above, I have laid myself under obligation to a number of articles which have appeared at one time and another in the newspapers and periodicals within the last century, and especially to certain contributions in the *Century Magazine*, the *Yachting Monthly*, the *Engineer* and in *Engineering*. For the rest, I have relied on material which I have myself collected, as well as on much valuable matter which has been courteously supplied to me by the various shipbuilding firms and steamship lines.

My thanks are also due for the courteous permission which has been given to reproduce photographs of many of the steamships seen within these pages. To the authorities at South Kensington I am indebted for the privilege of reproducing a number of the exhibits in the Victoria and Albert Museum. I wish also to thank the City of Dublin Steam Packet Company for permission to reproduce the *Royal William*; Mr. James Napier for the illustration of the *British Queen*; the Cunard Steamship Company for the various photographs of many of their fleet; also the Royal Mail Steam Packet Company, the Peninsular and Oriental Steam Navigation Company, Messrs. Ismay, Imrie and Co., Messrs. Anderson, Anderson and Co., the American Line, the Norddeutscher Lloyd Company, the Liverpool Steam Towing and Lighterage Company, Messrs. L. Smit and Co., the Ymuiden Tug Company, Messrs. Lobnitz and Co., Renfrew, the Mersey Docks and Harbour Board, Liverpool, Sir W. G. Armstrong, Whitworth and Co., Messrs. William Doxford and Sons, Sir Raylton Dixon and Co., Messrs. Cochrane and Sons, Selby, the Fall River Line, Messrs. A. and J. Inglis, Messrs. Thos. Rhodes and Co., the Caledon

Shipbuilding and Engineering Co., Messrs. Camper and Nicholson, Messrs. Cammell, Laird and Co., the Great Western Railway Company, the London and North Western Railway Company, the London and South Western Railway Company, the South Eastern and Chatham Railway Company, Messrs. Harland and Wolff, and Messrs. C. A. Parsons and Co. To the Right Hon. the Earl of Stanhope, to the New Jersey Historical Society, and also to the proprietors of the *Century Magazine* I wish to return thanks for being allowed to reproduce certain illustrations connected with Fulton's early experiments in steam navigation, and to the *Yachting Monthly* for permission to reproduce the diagrams of steam yachts and lifeboats.

Finally, I have to apologise if through any cause it should be found that in spite of extreme carefulness errrors should have found their way into this narrative. The nature of the subject is necessarily such that to have erred herein would have been easy, but I have been at great pains to prevent such a possibility occurring.

E. KEBLE CHATTERTON.

June, 1910.

CONTENTS

CHAPTER		PAGE
1.	Introduction	1
2.	The Evolution of Mechanically-Propelled Craft	12
3.	The Early Passenger Steamships	63
4.	The Inauguration of the Liner	104
5.	The Liner in her Transition State	145
6.	The Coming of the Twin-Screw Steamship	165
7.	The Modern Mammoth Steamship	183
8.	Smaller Ocean Carriers and Cross-Channel Steamers	215
9.	Steamships for Special Purposes	233
10.	The Steam Yacht	266
11.	The Building of the Steamship	282
12.	The Safety and Luxury of the Passenger	297
13.	Some Steamship Problems	309

LIST OF ILLUSTRATIONS

The "Olympic" . . . . Frontispiece
Hero's Steam Apparatus . . . . . . Facing page 18
Jonathan Hulls' Steam Tug Boat . . . . " " 30
The Marquis de Jouffroy's Steamboat . . " " 40
Patrick Miller's Double-hulled Paddle-boat . " " 42
Symington's First Marine Engine . . . . " " 42
Outline of Fitch's First Boat . . . . . . Page 45
The "Charlotte Dundas" . . . . . Facing page 46
The "Clermont" in 1807 . . . . . " " 46
Fulton's design for a Steamboat submitted to the Commission appointed by Napoleon in 1803 . Page 51
Fulton's First Plans for Steam Navigation . . " 57
Fulton's design of Original Apparatus for determining the Resistance of Paddles for the propulsion of the "Clermont," dated 1806 . . " 64
The Reconstructed "Clermont" at the Hudson-Fulton Celebrations, 1909 . . . . . Facing page 70
Paddle-wheel of the Reconstructed "Clermont" " " 70
Fulton's Preliminary Study for the Engine of the "Clermont" . . . . Page 75
Fulton's plans of a later Steamboat than the "Clermont-North-River," showing application of the square side connecting rod Engine . . " 77
The "Comet" . . . . Facing page 78
Engine of the "Comet" . . . . . . " " 78
S.S. "Elizabeth" (1815) . . . . . . " " 84
Russian Passenger Steamer (1817) . . . . " " 84
The "Prinzessin Charlotte" (1816) . . . . " " 90
The "Savannah" (1819) . . . . . . " " 90

The "James Watt" (1821) . . . . . *Facing page* 94
Side-Lever Engines of the "Ruby" (1836) . " " 94
The "Sirius" (1838) . . . . " " 96
The "Royal William" (1838) . . . . . " " 96
The "Great Western" (1838) . . . . . " " 100
Paddle-wheel of the "Great Western" . . " " 100
The "British Queen" (1839) . . . . . " " 102
The "Britannia," the First Atlantic Liner (1840) " " 102
The "Teviot" and "Clyde" (1841) . . . " " 110
Side-lever Engine . . . . " " 110
Launch of the "Forth" (1841). . . . . " " 112
The "William Fawcett" and H.M.S. "Queen" (1829) . . . . " " 112
Designs for Screw Propellers prior to 1850 . " " 118
The "Robert F. Stockton" (1838) . . . . " " 120
The "Archimedes" (1839) . . . . . " " 120
Stern of the "Archimedes" . . . . . " " 122
The "Novelty" (1839) . . . . . . " " 122
The "Great Britain" (1843) . . . . . " " 126
Propeller of the "Great Britain" . . . . " " 126
Engines of the "Great Britain" . . . . " " 128
Engines of the "Helen McGregor" . . . . " " 128
The "Scotia" (1862) . . . . " " 130
The "Pacific" (1853) . . . . " " 130
Maudslay's Oscillating Engine . . . . . " " 132
Engines of the "Candia" . . . . . . " " 132
The "Victoria" (1852) . . . . . . " " 134
The "Himalaya" (1853) . . . . . . " " 134
Coasting Cargo Steamer (1855) . . . . . " " 134
The "Great Eastern" (1858) . . . . . " " 138
Paddle Engines of the "Great Eastern" . . . " " 140
Screw Engines of the "Great Eastern" . . . " " 140
The "City of Paris" (1866) . . . . . " " 148
The "Russia" (1867) . . . . " " 148
The "Oceanic" (1870) . . . . " " 152

The "Britannic" (1874)	*Facing page*	154
The "Servia" (1881)	" "	154
The "Umbria" (1884)	" "	158
The "Orient" (1879)	" "	158
The "Austral" (1881)	" "	162
The "Victoria" (1887)	" "	162
The "Majestic" (1889)	" "	162
The "City of Paris" (1893) (now the "Philadelphia")	" "	166
The "Ophir" (1891)	" "	166
The "Lucania" (1893)	" "	170
The "Kaiser Wilhelm der Grosse" (1897)	" "	174
The "Oceanic" (1899)	" "	176
The "Cedric"	" "	176
The "Celtic"	" "	178
The "Kaiser Wilhelm II."	" "	180
Giovanni Branca's Steam Engine (1629)	" "	184
The Blades of a Parsons Turbine	*Page*	185
The Parsons Turbine	*Facing page*	186
The "Carmania" (1905)	" "	188
Lower half of the fixed portion of one of the "Carmania's" Turbines	" "	188
A Study in Comparisons: the "Magnetic" and "Baltic"	" "	192
The "Mauretania" when completing at Wallsend-on-Tyne	" "	198
Stern of the "Mauretania"	" "	200
The "Lusitania"	" "	202
The "Adriatic"	" "	206
The "George Washington"	" "	208
The "Berlin"	" "	208
The "Laurentic" on the Stocks	" "	210
The "Mooltan"	" "	216
The Starting Platform in the Engine Room of the "Mooltan"	" "	218

The "Balmoral Castle"	*Facing page*	220
The "Cambria" (1848)	" "	222
Engines of the "Leinster" (1860)	" "	222
The "Atalanta" (1841)	" "	226
The "Lyons" (1856)	" "	226
The "Empress" leaving Dover Harbour	" "	226
The Ocean Tug "Blackcock"	" "	234
The Passenger Tender "Sir Francis Drake"	" "	234
The 7,000 ton Floating Dry-dock under tow by the "Roode Zee" and "Zwarte Zee"	" "	236
The Salvage Tug "Admiral de Ruyter"	" "	238
The New York Harbour and River Tug Boat "Edmund Moran"	" "	238
The Paddle-Tug "Dromedary"	" "	240
The Bucket Dredger "Peluse"	" "	240
The Suction Dredger "Leviathan"	" "	242
The "Vigilant"	" "	242
The Telegraph Steamer "Monarch"	" "	244
Deck View of the Telegraph Ship "Faraday"	" "	244
The "Silverlip"	" "	246
Section of Modern Oil-tank Steamer	" "	246
The Turret-ship "Inland"	" "	248
Midship Section of a Turret-ship	" "	248
Cantilever Framed Ship	" "	250
The North Sea Trawler "Orontes"	" "	252
The Steam Trawler "Nôtre Dame des Dunes"	" "	252
Hydraulic Lifeboat	*Page*	255
A Screw Lifeboat	"	257
The "Inez Clarke"	*Facing page*	258
The "Natchez" and the "Eclipse" (1855)	" "	258
The "Empire"	" "	258
The "Commonwealth"	" "	262
Beam Engine of an American River Steamer	" "	262
The "City of Cleveland"	" "	264
An American "Whale-back" Steamer	" "	264

Typical Steam Yacht of about 1890 . . . . . *Page* 271
A Steam Yacht of To-day . . . . „ 275
The Russian Imperial Yacht "Livadia" . . *Facing page* 276
The Royal Yacht "Victoria and Albert" . . „ „ 278
The Royal Yacht "Alexandra" . . . „ „ 278
The S.Y. "Sagitta". . . . . . . „ „ 280
The S.Y. "Triad" . . . . „ „ 280
"Flush-decked" Type . . . . *Page* 283
"Three Island" Type . . . . „ 283
"Top-gallant Forecastle" Type . . . . . „ 284
"Top-gallant Forecastle" Type, with raised quarter-deck . . . . „ 284
Early "Well-deck" Type . . . . . . „ 284
"Well-deck" Type . . . . „ 285
"Spar-deck" Type . . . . „ 285
"Awning-deck" Type . . . . „ 286
"Shade-deck" Type. . . . . „ 286
The Building of the "Mauretania" (showing floor and part of frames) . . . . . *Facing page* 286
The "George Washington" in course of Construction . . . . „ „ 288
Bows of the "Berlin" in course of Construction „ „ 290
The "Berlin" just before her Launch . . „ „ 290
Stern frame of the "Titanic," February 9, 1910 „ „ 292
The Shelter Deck of the "Orsova" in course of Construction . . . . „ „ 292*a*
One of the Decks of the "Lusitania" in course of Construction . . . . „ „ 292*a*
Launch of the "Araguaya" . . . . . „ „ 294
Launch of a Turret-Ship . . . . . . „ „ 294
The "Suevic" ashore off the Lizard . . „ „ 296
The Stern Part of the "Suevic" awaiting the New Bow at Southampton . . . . „ „ 296*a*
The New Bow of the "Suevic" at entrance to Dock . . . . „ „ 296*a*

Charles Dickens's State-room on the "Britannia" . . . . *Facing page* 298
The Veranda Café of the "Lusitania" . . „ „ 300
First Class Dining Saloon of the "Adriatic" . „ „ 300
Dining Saloon of the S.Y. "Liberty". . . „ „ 302
Gymnasium of the S.Y. "Liberty" . . . „ „ 302
The Marconi Room on a Cunard Liner . . „ „ 306

STEAMSHIPS AND THEIR STORY

CHAPTER I

INTRODUCTION

In my previous book, "Sailing Ships and Their Story," which, indeed, this present volume is meant to follow as a complement of the story of the development of the ocean carrier, I ventured to submit the proposition that a nation exhibits its exact state of progress and degree of refinement in three things: its art, its literature, and its ships; so that the development of the ship goes on side by side, and at the same rate, as the development of the State. And if this was found to be true with regard to the vessel propelled by sails, it will be seen that the same can be affirmed with no less truth in respect of the steamship.

In setting out on our present intention to trace the story of the steamship from its first beginnings to the coming of the mammoth, four-funnelled, quadruple-screw, turbine liners of to-day, it is not without importance to bear the above proposition in mind. For though the period occupied by the whole story of the steamer is roughly only about a hundred years, yet these hundred years represent an epoch unequalled in history for wealth of invention, commercial progress, and industrial activity. The extraordinary development during these years, alone, not merely of our own country and colonies, but of certain other nations—of, for instance, the United

States of America, of Germany, of Japan—has been as rapid as it has been thorough. Consequently, if our proposition were correct, we should expect to find that the rate of development in the ship had been commensurate. Nor have we any cause for disappointment, for as soon as we commence to reckon up the achievements made in art and literature during the nineteenth, and the first decade of the twentieth centuries, and to compare the rate of progress of the ship during this same period, it seems at first not a little difficult to realise that so much should have been accomplished in so short a time.

When the inhabitant of the Stone Age had succeeded in putting an edge on his blunt stone implement, he had instantly "broken down a wall that for untold ages had dammed up a stagnant, unprogressive past, and through the breach were let loose all the potentialities of the future civilisation of mankind." It is by no means an unfitting simile if I suggest that we liken the invention of steam to the discovery of the potentialities of the edge. Until the coming of the former we may well say that progress, as we now know it, remained stagnant, at any rate in respect of *rapid* movement. Omitting other uses for steam not pertinent to our present subject, we may affirm that in annihilating space, in quickly bridging over the trackless expanse of oceans, steamships have succeeded in accelerating the development of the countries of the world.

Ever since the time when primitive man first learned to harness the wind in his navigation of the waters of the earth, there had always been sailing vessels of some sort. For, at any rate, 8,000 years there is a chain of evidence illustrating one kind of sailing craft or another, and the work of later centuries was but to improve and increase the capabilities of the sailing vessels handed down from one generation to the

other. But with the first experiments in steamships it was quite different. Here was a case of experimenting, with but few data on which to rely. For, granted that already some knowledge had been collected concerning the capabilities of steam, and notwithstanding the fact that a great deal more knowledge was extant concerning the art of shipbuilding, yet the condition of relationship between ships and steam was unknown, untried. How to generate the maximum of steam power at the lowest cost; how to apply this power in such a manner as to cause the hull to go through the water at a fair pace; whether the propelling power should find its expression at the side or the extremity of the ship—these and many other problems could be solved, not by previous history, but simply and solely by experimenting, as the primitive man had solved the problem of the mast and sail in their relation to the wind.

And yet it was scarcely probable that the value of the sail, which had been appreciated for so many thousands of years, should be suddenly found worthless. Inventions are no sooner born than they find themselves compelled in their weak infancy to fight for their lives against the militant conservatism of established custom. Seamen-descendants of ages and ages of seamen, themselves the most conservative of any section of society, were not likely to believe so readily that pipes and boilers were going to do as much for the ship as spars and sails. Nor, in fact, did they all at once. But something had to come as a greater propelling power than uncertain wind. For the world in the early part of this hundred years was waking up again after the dull Georgian period. It was perhaps rather a new birth—another Renaissance. Soon it began to get busy, and speed, not repose, became the general cry, whose

noise is heard now louder and louder each day on land as well as sea. Every known device of the architect and builder was employed to coax additional knots out of the sailing ship: all the improvements in sails and gear were utilised to this purpose. As the result of these demands the magnificent clippers doing their marvellous passages homewards evolved. But that was all too slow. Passengers and freights were in a hurry to get from shore to shore, and, later, perishable food supplies could not be entrusted to the sailing ship. And so, when once the steamship had appeared, even though not as a pronounced success, yet the spirit of the times was such that she should be encouraged as being likely to satisfy the cravings of an active, restless age.

In the history of human progress we find everywhere exemplified a continuous effort through centuries and centuries of change to obtain an end with the least expenditure of labour. It is one of the most striking characteristics of our nature that we proceed along that road offering the least resistance and requiring the smallest amount of endeavour. Not more true is this assertion to-day than in the ages which have sunk into oblivion, and but for this human instinct, or failing, the progress of the world would have been impossible. The prehistoric man found the action of paddling his dug-out so irksome and wearying that he invented the sail as a means of harnessing the wind to do his work, and, as a result, what does the world not owe to his apparent laziness? How else would new countries have been discovered and peopled, commerce extended to nations beyond the seas, untilled areas made to yield their fruitful produce, and wealth amassed by production and exchange of commodities? It was not until Europe had at last begun to build her big caravels and caracks,

and to learn how to handle them with adequate seamanship, that the art of navigation advanced so far as to enable Columbus to sail across the Atlantic, and to lay the foundation of the prosperity of the New World. To have attained such a feat by the means of physical propulsion would have been impossible; it was only by the invention of the sail and the perfection of the sailing ship after many centuries of experimenting that this came about. For man's endurance is hedged in by stern limits. He can only work for part of the day, and he must eat and sleep. But by yoking the wind to the sail the voyage could be continued without the necessity for plying the oar, and most of the crew could be below at their rest or their meals.

But the sailing ship, too, has her limitations. When the wind drops her range of usefulness automatically ends. When the wind becomes contrary, or rises in sufficient fierceness as to become a gale, the sailing ship again loses some of her utility, whilst tides and currents in like manner combine to impede her advance from one port to another. And so, realising all these harassing circumstances, man has ever had a desire to shake himself free from such irritating restrictions, to assert his own independence of winds and seas and tides, and to steer his ships where he liked, and as fast as he liked with the minimum effort.

And yet he has been a very long time indeed finding the means of rising superior to the forces of Nature. He has had to fight very hard against heavy odds, he has had to devise no end of ingenious methods, most of which have been utterly useless, and many a man, overjoyed at his discovery of a sure means of overcoming the problem of propelling craft without sails or oars, has found at the last that in practice it was

unworkable or too costly. Some have died from sheer want through sacrificing their all to this one end; others, rendered more sensitive by the ridicule and scorn of their fellow-men, have, on witnessing their own failure, died of a broken heart, and been reckoned by the least discerning as among those who wasted their lives in pursuing a shadow, frittered their time and money in seeking to attain the unattainable, and left behind them no monument except a pile of unworkable propositions and theories.

But no generation is at any time of its career independent. From its first moments it is under a debt to those which have come and gone. Literature is but a collection of data amassed by our predecessors and handed down to the next age, which adds a little more to what is already known. It is scarcely possible to point to one man and say that he alone was the inventor of any new theory or device, although in carelessness we actually so speak. His own conclusions have been based on the accumulation of what his predecessors have left for him; and it is the same with the invention of the steamship. Some writers of different nationalities have patriotically upheld one man or another as the father of the steamship with a zeal that does more credit to their national loyalty than to their sense of historical fairness. In point of fact, although in different epochs one man has been more successful in practical experiment than another, we cannot, at any rate in the history of the steamship, give to that man a place of honour to the exclusion of all those who have gone before. Without their help he would never have succeeded. Their failures, even if they left him little to work on, at least showed him what to avoid. As an example we might here cite the instance of using a propeller shaped after the manner of a duck's foot, which,

being a close copy of the method employed by a species of animal which has its being on the surface of the water, appealed powerfully to more than one inventor as the likely way to solve a great problem; just as the early days of aviation were wasted in endeavouring to follow too closely the methods of locomotion adopted by birds. The years of man are but threescore and ten, and he cannot go on wasting his allotted time in trying and discarding all the experiments possible; but from the disordered mass of accumulated data he can extract just those which have any semblance of sound sense and practicability, from which he can deduce his own new theory and put it to actual test.

Because, then, of this mutual inter-dependence we shall give the palm to no individual, but endeavour to show how, step by step, the ship has shaken herself free of entire slavery to the wind, one age helping her a little in her ambition, others sending her forward farther still towards her goal. Chance plays so curious a game with progress. A genius may spring up too early or too late to be appreciated. He may be hailed as a dangerous lunatic or as a benefactor of mankind, according to whether the time was ripe for his appearance.

Papin, as we shall see presently, was born out of due season. His fellow-men did not want his steamer, so they smashed it to pieces. Solomon de Caus, who showed that he knew more about the application of steam than anyone who had ever lived, was shut up as a madman, whereas Fulton, another man of rare genius and wonderful fertility of invention, has recently had his centenary celebrated and fêtes in his memory held, lest the recollection of his great gift to mankind should be easily forgotten. But Fulton was just the kind of man to acknowledge his dependence on the work of his predecessors,

that Papin was able to supply the key to the question of the mechanical propulsion of ships. Even if it were possible to prove that he had never acquainted himself with the theories of de Caus and the Marquis of Worcester, that argument would avail but little, for the solution was bound to come sooner or later; it was inevitable. There must be, man reasoned, some means for propelling a ship along the water other than by sails or oars. The Chinese had been working at the idea, the Romans had at least attempted it; through the Middle Ages there had been actually accredited instances, and so the eighteenth century was not too soon for its accomplishment. Thus, when Papin determined to apply steam power to vessels, he was just one of those many benefactors of the world who have succeeded by means of Nature to overcome Nature: by employing fire and water to overcome water and space.

Let us, then, turn to the next chapter and see something more of the different methods which were tried before the satisfaction of full and undoubted success rewarded man in his struggle against the limits to his freedom. As this is a history rather of steamships than of all kinds of mechanically-propelled craft, we must examine not all the ingenious theories and the wild conceptions which many minds in many ages have conceived for propelling ships by mechanical means other than steam (for with those alone we could fill this book), but having shown something of the main principles which underlay these, we shall pass on to tell, for the benefit of the general reader, something of the vicissitudes through which has passed that swift and majestic creature which carries him across vast oceans and broad turbulent channels, as well as the peaceful waters of the land-locked lake and river. For

this reason, while not omitting anything that shall contribute to the better understanding of the story, we shall omit from our study such technical details and theories as came to nothing practical and, notwithstanding their importance in fashioning the future of the steamship, are of less interest to the average reader than to the shipbuilder and engineer. Modern activity is now so rapid; event follows event so quickly; the ship of yesterday is already made obsolescent by a newer type, that we cannot fairly be accused of living too near the period to obtain an accurate perspective. Whether steamships will flourish much longer, or whether they will in turn be surpassed, as they have ousted the sailing ship, is a debatable proposition. At any rate, to anyone who has at heart one of the greatest and most powerful forces in the spread of civilisation, the story of steamship evolution, from comparative inutility to a state of efficiency which is remarkable even in this wonder age, cannot but appeal with an attractiveness commensurate with its importance.

CHAPTER II

THE EVOLUTION OF MECHANICALLY-PROPELLED CRAFT

When the prehistoric man was returning home from his day's fishing or hunting, and the evening breeze had died away to a flat calm so that the primitive sail became for the time a hindrance rather than a saving of labour, and the tired navigator was compelled reluctantly to resort to his paddles once more—it was, no doubt, then that our ancestry was first inoculated with the germ for desiring some mechanical form of propulsion, and the fever went on developing until it broke out in full infection when the possibilities of steam were beginning to be weighed.

The earliest records of the employment of some artificial means for sending the ship along are not preserved to us, although it is certain that repeated attempts were made in many ages to do without oars and sails. When slave labour was cheap and plentiful, and this could easily be turned into propelling power, perhaps it was hardly likely that there would be much incentive for discovering or rediscovering such forces as steam to do the work of physical energy. It seems to me to be a curious and interesting fact that it was not until the freedom of the individual from some sort of slavery and servitude—whether belonging to ancient times or the Middle Ages—began to be asserted that there was any real progress made in labour-saving devices. The dignity of man, and his superiority as a being possessed of intelligence and dis-

cernment, and, consequently, his right to be considered as something more than a drawer of water, a hewer of wood, and the motive force for any method of transport, had fully to be recognised and appreciated before means were earnestly sought to save human labour. The cry of the last few years and the tendency exhibited by many world movements have been all for asserting the right of the individual. The French Revolution, the American War of Independence, the rise of Socialism of some sort or another in most civilised countries, have happened collaterally with the progress of machinery, and the development of power independent of physical force, necessitating less and less the expenditure of human energy. Never in the history of the world has so much been accomplished for obtaining mechanical energy as within the last hundred and fifty years, and never perhaps has the individual been able to possess himself of so much freedom.

But even in those days when slaves could be made to work to the limits of their endurance, it is fairly evident that man believed that there was a future for the mechanical propulsion of ships, and the usual form which this took was of applying paddle-wheels to the side of the ship, and revolving these by means of a capstan turned either by slaves or by oxen. The Chinese, it is scarcely to be wondered at, adopted this means, and so also did the Romans. In 264 B.C., when Appius Claudius Caudex one dark night crossed the Straits of Messina to Sicily, he transported the troops in boats propelled by paddle-wheels through the medium of capstans revolved by oxen, and there is in existence an ancient bas-relief which shows a galley with three wheels on either side to be used for this purpose. Over and over again this same idea was exploited, and even as recently as 1829 Charles Napier, a British naval officer, when

he was in command of the frigate *Galatea*, was by special permission of the Admiralty allowed to fit her with paddles, which were worked by winches on the main deck. He found that in a calm he could thus get his ship along at three knots an hour, and tow a line-o'-battle ship at one and a half knots. But it was noticed then, what experimenters of this nature always found in every age, that, firstly, this method of capstan-plus-paddle-wheels was good only for a short distance; and, secondly, that so great an expenditure of physical force could be more advantageously applied by using the old-fashioned method of rowing.

Many a student and philosopher pictured in his mind some novel method for doing away with sails and oars, among whom we might mention Roger Bacon; but most of these theories seem not to have gone farther than the walls of the study. In 1543 another attempt was made by one Blasco de Garray, on June 17. Himself a native of Biscay, he proceeded to Barcelona, and experimented first with a vessel of 109 tons, and later with one of about twice the size. For many years it was commonly, but erroneously, stated that this was the first steamship. Apart altogether from the unlikeliness of this being the case at so early a date, it has now been proved to be little better than a fable based on insufficient evidence. Even to this present day this inaccuracy is still repeated, and it is not out of place to emphasise the fact yet again that de Garray's was *not* a steamship. Special research has been undertaken in the Royal archives of Simancas by able and discriminating students, and the result is that, while it was found that two separate experiments were made with two different vessels, and that one ship had a paddle-wheel on either side worked by twenty-five men, and the other ship

by forty men, and that a speed equal to three and a half English miles per hour was obtained, yet there was discovered among these manuscripts no mention whatsoever of the use of steam. The vessels were found to steer well, but the same conclusion was again arrived at—viz. that for a passage of any length it was far easier to use oars.

The idea, however, was not dead, and we find it coming up again in the time of Elizabeth. During her reign there were numbers of little books issued to make the seamen more efficient, and these, of course, deal with the sailing ship. One of the most entertaining that I know of is that entitled "Inventions or Devises Very necessary for all Generalles and Captaines, or Leaders of men, as well by Sea as by Land: Written by William Bourne." It was published in London in 1578, and is full of fascinating matter for preventing the enemy from boarding ships, and useful tips for sinking him even when he is superior in strength and size to the ship he is attacking. Bourne mentions the following "devise" on page 15:—"And furthermore you may make a Boate to goe without oares or Sayle, by the placing of certaine wheels on the outside of the Boate, in that sort, that the armes of the wheeles may goe into the water, and so turning the wheeles by some provision, and so the wheeles shall make the Boate to goe." And the next "devise" refers to the fact that "also, they make a water Mill in a Boate, for when that it rideth at an Anker, the tyde or streame will turne the wheeles with great force, and these Milles are used in France."

In another interesting sixteenth century book, full of curious and wonderful machines, entitled "Theatrum Instrumentorum et Machinarum Jacobi Bessoni, Mathematici ingeniosissimi," published in 1582, there are detailed illustrations

and descriptions of a curious ship which is in shape something like a heart, the bow being the apex, so to speak; the stern has two ends, between which is fitted a species of paddle-wheel of unusual kind. It consists of a cigar-shaped object of wood, not unlike a modern torpedo, but broader. Through this is an axle which allowed the wheel to revolve freely, and on the axle at either end rests a vertical spar, which is fastened to another spar at the top parallel with the wheel. From the centre of this spar an enormous kind of mast or sprit rose high up into the air, which was worked by means of a tackle and ropes leading down to a winch, turned by two men. Thus, if the reader will imagine an object resembling one of those rollers employed in the preservation of a cricket pitch, but made of wood instead of metal, he will get something of the shape of this curious machine. Besson evidently thought a great deal of this invention and speaks of it as "inventum vix credibile," but it was a clumsy method and cannot really have had many virtues to commend it.

Seven years after Besson's publication there appeared another book which throws light on the prevailing passion for mechanical propulsion, though it refers back to the time of the ancient galley. In "The History of Many Memorable Things Lost, which were in use among the Ancients . . . written originally in Latin by Guido Pancirollus, and now done into English Vol. i.," published in London in 1715, but first issued in 1589, the following statement is made on page 120:—"I saw also the pictures of some ships, called Liburnæ which had three wheels on both sides, without, touching the water, each consisting of eight spokes, jetting out from the wheel about an hand's breadth, and six oxen within, which by turning an engine stirr'd the wheels, whose Fellys

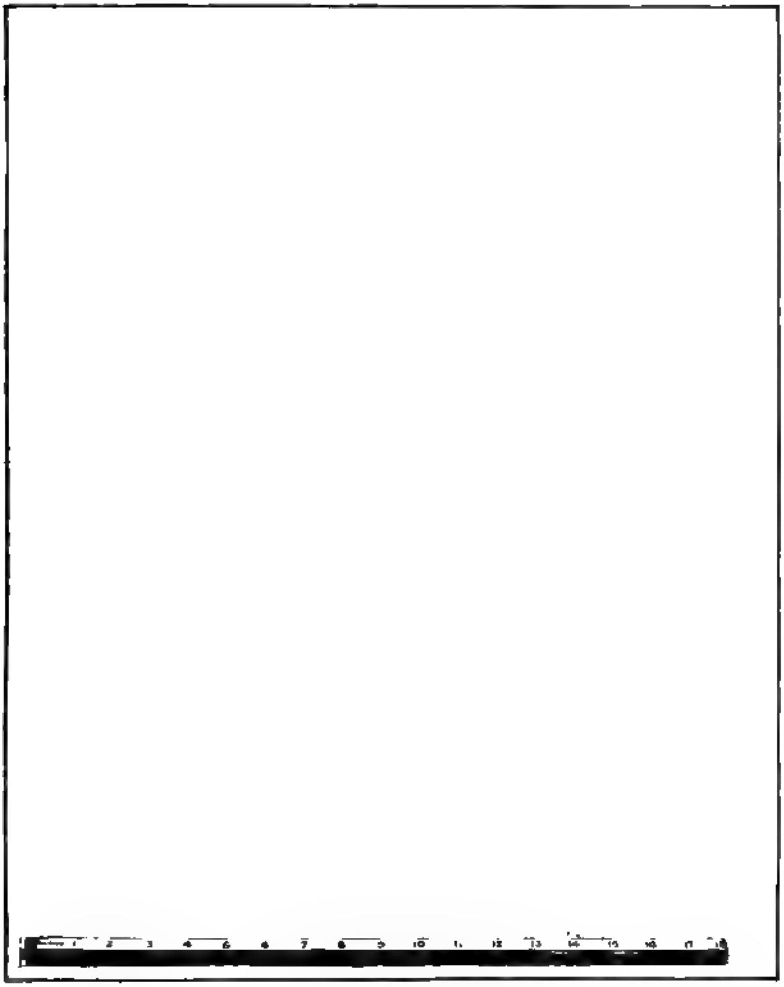
[spokes], driving the water backwards, moved the Liburnians with such force that no three-oar'd gally was able to resist them." This would seem to confirm the statement that the ancient inhabitants of the Mediterranean certainly employed the paddle-wheel.

But a year before Pancirolli published his book there appeared another interesting work, which shows yet again that the employment of paddle-wheeled craft was far from non-existent. There is a scarce book in the British Museum, published in 1588, entitled "Le Diverse et Artificiose Machine del Capitano Agostino Ramelli," which is illustrated with some highly informative plates. Fig. CLII. shows a kind of pontoon, to be employed by the enemy in attacking a town from the other side of a stream or river. A horse brings a rectangular shaped construction down to the water's edge, where it is launched and floats. Everywhere this kind of built-up dray is covered in, but in the bows a man is seen firing his harquebus from his protected shelter, while on either side of this craft a paddle-wheel is seen revolving with its six blades, that are not straight, as in the modern wheels, but curved inwards like a scythe. The illustration shows these wheels being turned by a man standing up inside; the wheels are quite open, without paddle-boxes. An oar projecting at the stern enables the craft to be steered.

We see, then, that that earliest form of ship propulsion by mechanical means, the paddle-wheel, was thoroughly grafted into man's mind long before he had brought about the steamboat. We cannot give here every theory and suggestion which the seventeenth century put forward, but we can state that during this period various patents were being taken out for making boats to go against wind and tide, some

of which were conspicuously distinguished by their display of ingenuity to overcome the forces of Nature. We come across all sorts of ideas for "to make boats, shippes, and barges to go against strong wind and tide," "to draw or haul ships, boates, etc., up river against the stream," "to make boates for the carryage of burthens and passengers upon the water as swifte in calms and more saft [*sic*] in stormes than boates full sayled in greater wynes." The Marquis of Worcester, in 1663, published a little book entitled "A Century of the Names and Scantlings of Inventions," and he himself patented an invention for sending a boat against the stream by using the actual force of the wind and stream in a reverse manner. But the fact to be borne in mind for our present purpose is that from all these ingenious propositions nothing practical ever evolved that was found to be of any service to man, or the transportation of his commerce. At any rate, there is no record of this.

Now that we have traced in outline the vain attempts at physical propulsion, let us turn to take a view of the evolution of that other invention whose advent alone delayed the practical utility of the paddle-wheel to boats. Who shall say how it was that steam came first to be regarded as a means of giving power? In certain parts of the world, where geysers and boiling springs existed, man must naturally have been struck by the elastic force which steam possessed. An intellect which had any leaning to the side of practical economy must have reasoned that here was a valuable force running to waste, which might have been employed in the service of mankind, just as the swift-running rivers could be made to turn the water-wheels. But, as we said just now, steam was not wanted yet, for human labour was too cheap to bother about it; and



HERO'S STEAM APPARATUS.

From the Exhibit in the Victoria and Albert Museum, South Kensington.

we might remark incidentally that it was owing to this same cheapness that the galley, or rowing craft, was encouraged for many centuries in the Mediterranean, to the partial exclusion and great discouragement of the big sailing ship. Indeed, slavery, or abundance of cheap, compulsory labour, has been the means of holding back the progress of the world. Had the big sailing ships come at an earlier date the far-off countries would have been discovered much sooner, and the study of the properties of steam—or some other means as the equivalent of physical power—would have been regarded with a greater enthusiasm. Perhaps it would be more accurate to speak of the re-discovery of steam than of its invention: for as early as 130 B.C. Hero, of Alexandria, had written a treatise on "Pneumatics," and described a light ball supported by a jet of steam which came out of a pipe into a cup, much as one sees in the rural fairs of to-day the same idea used when the force of water raises a light ball for the bucolic rifleman to shoot at. Hero also referred to the "aeolipile," which was a hollow ball mounted on its axis between two pivots, one of which was hollow and acted as a steam pipe. Two nozzles formed part of the ball and were fitted at right angles to the pivots on which the ball revolved, and owing to the reaction caused by the escape of the steam from the jets touching the ball the latter was made to revolve. This is well illustrated in the plate facing page 18.

From the time of Hero to the seventeenth century ensues a wide hiatus, although in the meantime there were not wanting some who now and again added slightly to the body of knowledge which the world possessed on the subject. Of these we might mention such names as Archimedes in the second century B.C., and Mathesius in the sixteenth century A.D. But Solomon

de Caus, or Carrs, in the first half of the seventeenth century showed that the steam given off by boiling water could be used for raising water, and Giovanni Branca, about the same time, brought about what is really the progenitor of the modern turbine. In this seventeenth century, also, another ingenious Italian, Evangelista Torricelli, proved that the atmosphere in which we live possessed weight, and to-day everyone is aware that this is so, and that the pressure of the air is 15 lb. per square inch. The working of the mercurial barometer is the simplest proof of this. We shall see presently how an isolated fact unearthed in one age becomes the foundation of the mighty success of a later inventor, and thus the assertion which we made on an earlier page, that the credit of inventing the steamboat belongs neither to one man nor to one age, is not devoid of truth.

Otto von Guericke, about the middle of the same century, showed the practical utility of producing a vacuum, of which the syringe and the common suction pump are such excellent examples. But we are not writing a history of inventions, nor of steam, but of the steamship, and we shall pass on presently to see how each of these separate important discoveries eventually blended to form the subject of our present study. In 1668 Edward Somerset, the second Marquis of Worcester, to whom we have already referred, also published his description of "An Admirable and most Forcible Way to drive up Water by Fire," and in this year he obtained protection by Act of Parliament for his "water commanding engine." When he had interested himself so much in the problem of sending a craft against a current, and simultaneously was obtaining success in the development of steam power, it certainly seems a little strange that the Marquis did not advance

just that one step farther which was necessary to complete the syllogism, and apply steam for the purpose of solving the problem of going against the tide or stream. That, however, was reserved for another inventor, and of a different nationality.

And so we come to one whose name is deserving of especial mention in the history of the steamship, for it was he who was the first to do what myriads of others have since done. Many writers have asserted wrongly that this man or the other was the first to succeed: they have gone back as far as de Garray and as short a distance as Fulton. Some have stated timidly and with reserve that Denis Papin is said to have been associated with this honour. But there can be no manner of doubt that to Papin certainly belongs the high distinction of having caused the steamboat to be an actual fact and not merely a figment of imagination. Papin was a French engineer, who, being a Calvinist was, after the revocation of the Edict of Nantes, obliged to go into exile. For that reason, therefore, he betook himself to the Court of the Landgrave of Hesse, where he found refuge. In 1690 he published a suggestion for obtaining power by means of steam. His idea was to have a cylinder made of thin metal; water was to be placed therein and heated. In the cylinder were to be also a piston and rod on which was a latch, and when the water had been heated sufficiently so that enough steam had been generated, the piston would be moved upwards and be kept there by means of the latch. Thereupon the fire was to be taken away, and, the steam then condensing, as soon as the latch was loosed the piston was bound to drop to the bottom of the cylinder; and if a rope and pulley were attached to the rod, then the descent of the piston would be able to raise

a weight at the end of the rope. This was practically what was afterwards known as the atmospherical engine, and Papin was of the opinion that it could be employed for draining rivers, throwing bombs and other purposes. But it is especially notable for our purpose that he firmly believed that it could be employed for rowing a craft against the wind, and indeed would be preferable to the working of galley slaves for getting quickly over the sea; for men, he explained, occupied too much space, consumed too much food, and his tubes and pumps would make a far less cumbersome arrangement. It is worth while noting that the idea of these early inventors of the steamboat was not so much to *propel* the ship as to *row* her mechanically by oars or paddles. We still call them paddle-wheels rather than propelling wheels, and the early wheels used for the steamboat were practically paddles placed crosswise, with a blade at the end of each spar. When fitted to an axle, of course, they moved in a circular fashion. The French "roue à aubes," which is the expression that these French inventors made use of in describing their creations, conveys precisely the same idea.

Papin, casting about for some method of bringing about the steamboat, suggests the use of these rotatory oars, and mentions having seen them fixed to an axle in a boat belonging to Prince Robert of Hesse. This latter was one more of those attempts to propel a craft by physical means, for these revolving oars were turned by horses. Papin, in considering the matter, thought that instead of horses the wheels might be made to go round by steam force, and in 1707 he actually constructed the first steamboat, which he successfully navigated on the River Fulda, in Hanover. He even did so well that he set off in her to steam down to the sea and cross to London; but,

of course, the old, conservative prejudice of the local boatmen was bound to make its appearance as soon as so historical a craft had shown her ability. And so, arriving at Münden, the watermen, either through fear that this new self-propelling craft would take away their livelihood through inaugurating a fresh era, or, being envious of a success which no man had ever before obtained, they attacked this steamboat, smashed it to pieces, and Papin himself barely escaped with his life. Thus, a craft and its engines, which to-day would be welcomed by any museum in the world, was annihilated by the men who had the privilege of witnessing the first steamship. Papin never got over the grief caused by so cruel a reception of his brilliant labours, and it is deplorable to think that such scant encouragement was possible. Besides being the successful originator of the steamboat, he was also the inventor of the safety valve.

The publication of Papin's correspondence with Leibnitz puts the case beyond all possibility of doubt, and the reader who cares to pursue the subject will find the facts he requires in "Leibnizens und Huygens' Briefwechsel mit Papin," by Dr. Ernst Gerland. From this we see that Papin had already published a treatise dealing with the application of heat and water. In a letter, dated March 13, 1704, he wrote to Leibnitz of his intention to build a boat which could carry about four thousand pounds in weight, and expressed the opinion that two men would be able to make this craft easily and quickly to ascend the current of a river by means of a wheel which he had adjusted for utilising the oars. That Papin made no aimless plunge, but went into the matter scientifically, is quite clear. He studied carefully the important fact of the resistance which is offered to a vessel passing through the

water, and thus found what he believed to be the correct lines on which his ship was to be built. He shows that he had been hard at work expanding his theories, and was longing to have the opportunity to put them to a practical test. On July 7, 1707, he writes to say that he has many enemies at Cassel (where he was then sojourning) and contemplates going to England; and in asking permission so to do he brings forward the plea that it is important that the new type of ship should have a chance of proving its worth in a seaport such as London. He does not conceal the great faith which he reposes in this novel craft: "*qui, par le moien du feu, rendra un ou deux hommes capables de faire plus d'effect que plusieurs centaines des rameurs.*" Then, writing again to Leibnitz, also from Cassel, under date of September 15 of the same year, relating the result of his experiment of this first steamboat, he remarks: "*Je Vous diray que l'experience de mon batteau a été faitte et qu'elle a reussi de la manière que Je l'esperois: la force du courant de la riviere ètoit si peu de chose en comparaison de la force de mes rames qu'on avoit de la peine à reconnoitre qu'il allât plus vite en dêcendant qu'en montant.*"

With such statements as these before us, we can no longer be in any doubt as to the first author of the steamboat.

Papin had discovered a method of producing a vacuum by the condensation of steam, but Thomas Savery is one of the many instances of the case where two men in different countries were working separately and unknown to each other at a common problem. The latter had patented an apparatus for raising water by the impellent force of fire so far back as the year 1698, or nine years before Papin's steamboat made her appearance; but he had also independently discovered a method of producing a vacuum by the condensation of steam

just as had Papin. And this same Savery had shown that the same problem which Papin had succeeded in solving was also interesting himself: for he had gone so far as to ask for a patent for an invention for moving a paddle-wheel on either side of a ship by means of a capstan, which capstan was to be revolved by men. Eventually it occurred to him, as it had not occurred to the Marquis of Worcester, that steam might be employed as helpful to ships. Nevertheless, Savery did not carry this idea to any practical test.

We come now to Thomas Newcomen, who, notwithstanding the fact that his home was at Dartmouth, where in the Elizabethan years so much had been done in connection with shipbuilding and the sending forth of so many naval expeditions across the seas, does not seem ever to have done anything directly for the development of the steamboat. But indirectly Newcomen did much, and the machine which he introduced, and with which his name is inseparably connected, was practically an English equivalent of Papin's atmospheric engine, to which we have already referred. Newcomen's engine is important to us, inasmuch as it embodied in a practical manner the main characteristics of what eventually became the familiar reciprocating steam engine; and had it not been for this, Watt might not have evolved his historic engine, and consequently Fulton not succeeded as he did. I shall endeavour not to weary the non-technical reader, but I must pause a moment here to give some idea of the nature of Newcomen's engine, because of the close relation which it bears to the subsequent development of the steam engine as fitted in ships and boats. It consisted, then, of a vertical cylinder, which, unlike our modern cylinders, was open at the top. It was provided with a piston to which were attached chains that

connected with one end of a beam, the centre of the beam being so fixed as to allow it to oscillate. Steam was generated in a boiler, on the top of which was a primitive cylinder, and by opening a valve, steam was admitted into the cylinder and so pushed up the piston. When the piston had reached the top of the cylinder the valve was closed so that the steam was shut off. Then cold water from a cistern was allowed to enter the bottom of the cylinder, and by this means the steam was condensed, so causing a vacuum; by the pressure of the air—which, as already mentioned, is 15 pounds to the square inch—the piston was forced down again. We get here, then, the essential features of that steam engine which is so familiar to all who travel by land or by sea. But these early atmospheric engines were not invented for the purpose of transport: it was for the pumping of water from mines that they were principally contrived, and in the case of the Newcomen engine, the other end of the beam opposite to that which was worked upwards by steam pressure (and downwards by atmospheric pressure) was attached to pump-rods that worked in connection with the buckets for pumping out the water. Thus, like the movement of the see-saw, when the piston-rod was down at the bottom of the cylinder the pump-rods were correspondingly elevated, and vice versa. As soon as the piston descended to the base of the cylinder through the cessation of the vacuum the spray of cold water was stopped, and steam was again admitted into the cylinder to cause another upward stroke. At the same time it was necessary to discharge the hot water which had accumulated at the bottom of the cylinder, and this was done through a pipe fitted with a valve which would not allow of its return; any air admitted with the steam and the cooling water was blown out through a snifting

valve (so-called because of the noise it makes) as the powerful steam came in. But, the reader may ask, what about the open top of the cylinder? How can it be any good to use an uncovered cylinder in conjunction with steam? The answer is, that since the top of the piston was always kept flooded with water, all air was excluded.

We have thus seen the steam engine in its most elementary form; how that it employs boiling water until it becomes steam which is then admitted to a cylinder and by its own force moves a tight-fitting disc or piston up and down. We have also seen that by attaching a rod to this disc, and, further, by connecting this rod to a beam, we can make the latter go up (by means of the steam pressure) or come down (through the pressure of the air). In order to effect the latter we have remarked the fact that a vacuum had to be made by condensing the steam through spraying cold water.

With this explanation in the mind of the general reader, to whom engineering matters do not usually appeal, we may proceed with the progress of our story, and pass on to the year 1780, when a method differing entirely from any that we have yet mentioned was brought forward. Strictly speaking it had nothing to do with steam, but, as we shall see when we come to consider the subject of steam lifeboats, it embodied an idea which could only be satisfactorily employed by the adoption of steam. In the year mentioned there was published a little book under the title "Specimina Ichnographica: or a Brief Narrative of several New Inventions and Experiments: particularly, The Navigating a Ship in a Calm, etc.," by John Allen, M.D. The author's idea was to propel a ship by forcing water, or some other fluid, through the stern by means of a proper engine. To this end he experimented with a tin boat

11 inches long, 5 inches broad and 6 inches deep. Placing this little ship into stagnant water, he loaded it until it sank in the water to a depth of $3\frac{3}{4}$ inches. Into the boat he also placed a cylindrical-shaped object 6 inches high and about 3 inches in diameter and filled it with water. At the bottom of the cylinder was a small pipe, a quarter of an inch square, and this led through the stern of the craft at a distance of an inch and a half below the surface of the water in which the boat was floating. As soon as Allen removed his finger from the outlet of the pipe in the stern the water, of course, ran out from the cylinder, and this action caused the boat to travel, the speed being reckoned, in the case of the model, at about one-fifth of a mile per hour. Although nothing actually came of this theory at the time, it is none the less perfectly workable, with some adaptations, and some of the steam lifeboats, in order to avoid using propellers, which are liable to get foul of wreckage when going alongside a ship in distress, have an elaboration of this principle. They are propelled by engines which work a pump that drives a stream of water through pipes placed below the water-line in much the same manner as in Allen's model. Allen at first contemplated working the pumps by men, and then causing them to be driven by an atmospheric steam engine. A similar device was employed in Virginia, U.S.A., by James Rumsey in 1787. In his boat water was sucked in at the bow and ejected at the stern. It was found that as long as the vessel travelled at all she went at the rate of four miles an hour, but as she only covered less than a mile and then stopped, it cannot be said that this experiment was conclusive. In 1788, the following year, however, another boat was made actually to go a distance of four miles in one hour, and the

device was patented in that country during the year 1791, but Allen had already patented his invention in England thirty years earlier.

It is when we come to Jonathan Hulls or Hull that we encounter the first Englishman to apply steam to ships. Hulls was a native of Gloucestershire, who, in 1736, patented a method of propelling vessels by steam, and in the following year issued a booklet on the subject of his invention which was subsequently reprinted. The title reads thus: "A Description and Draught of a New-Invented Machine for Carrying Vessels or ships out of or into any harbour, port or river, against wind and tide or in a calm . . . by Jonathan Hulls." His idea was to provide a steam tug so that it should be able to render beneficial service to those sailing ships accepting it. His preference for placing the "machine," or engines, into a separate ship, and thus using her as a tug-boat, instead of installing the engines on board each vessel was because he believed the "machine" might be thought cumbersome and take up too much room in a vessel laden with cargo. But besides the advantage of having a tow-boat always in readiness in any port, he suggested that an old ship which was not able to go far abroad could well be adapted for receiving this "machine."

"In some convenient part of the Tow-Boat," he explains, "there is placed a Vessel about two-thirds full of Water, with the Top close shut. This Vessel being kept boiling, rarefies the Water into a Steam: this Steam being convey'd thro' a large Pipe into a Cylindrical Vessel and there condens'd, makes a Vacuum, which causes the weight of the Atmosphere to press on this Vessel, and so presses down a Piston that is fitted into this Cylindrical Vessel in the same manner as

in Mr. Newcomen's Engine, with which he raises Water by Fire."

It will thus be seen that Hulls was an adapter of Newcomen's atmospherical engine to marine purposes rather than an actual inventor of something new and unheard of. But Hulls seems to have anticipated this criticism, for he adds: "if it should be said that this is not a New Invention, because I make use of the same Power to drive my Machine that others have made use of to Drive theirs for other Purposes, I Answer, The Application of this Power is no more than the Application of any common and known Instrument used in Mechanism for new-invented Purposes."

We have already noticed that the most which Newcomen could get out of his engine was an up-and-down movement, which was all very well for the purpose for which it was intended, namely, pumping up water, but before it was applicable for propelling a ship the power had to be adapted to give a rotary motion. The accompanying illustration, which is taken from Hulls' specification for his patent, and reproduced in the booklet mentioned above, will afford some idea of his proposal. In the lower half of the picture the "tow-boat" is seen in imagination hauling an eighteenth century full-rigged ship, a performance which in actual truth she never achieved. There is, in fact, some doubt as to whether Hulls ever did put the idea to a practical test. Admiral Preble, a distinguished American Naval officer, in his "Chronological History of the Origin and Development of Steam Navigation," published in Philadelphia in 1883, a volume which contains a vast amount of interesting detail up to that date, says that Hulls did not produce a satisfactory experiment. Scott Russell, one of the greatest authorities on such matters in the nine-

JONATHAN HULLS' STEAM TUG-BOAT.

After the Drawing attached to his Specification for the Patent.

teenth century, affirmed that Hulls did carry out his theory in definite shape, and the recent "Dictionary of National Biography" also states that at any rate he experimented with a vessel on the River Avon in the neighbourhood of Evesham in 1737. One thing is certain, that whatever merits the proposition might have had in certain respects, it was, commercially, a complete failure. On the other hand, in enunciating a method of converting the rectilineal motion of the piston-rod into a rotary movement Hulls undoubtedly showed the direction in which others were to follow.

In the upper half of the illustration of Hulls' drawing, beginning at the bottom right-hand corner, we see the details of his "machine." *P* is the pipe which comes from the furnace and brings the steam to *Q*, the cylinder in which the steam was also condensed. (This last remark is important to bear in mind, as we shall see later to what extent this feature was modified.) The point marked *R* is the valve which enables the steam to be cut off from entering the cylinder whilst that amount of steam which has already been allowed to go in is being condensed. The other small pipe *S* conveys the cooling water which condenses the steam in the cylinder, and *T* is the cock which lets in the condensing water after the cylinder is full of steam and the valve is shut. *U* is the rope which is fixed to the piston that slides up and down the cylinder, and this is the same rope that goes round the wheel *D* in the machine shown in the larger illustration.

In this latter picture, too, wherein the tow-boat is seen steaming along, *A* denotes, of course, the chimney "coming from the furnace," while *B* is the tow-boat and *CC* are the two pieces of timber which are framed to support the machine. It will be noticed that inboard are three wheels marked

respectively *Da, D,* and *Db*. These are on one axis and receive the ropes as shown. *Ha* and *Hb* are two wheels also on the same axis projecting beyond the stern, and the six fans or paddles are marked *I*, which move alternately in such a manner that when the wheels *Da, D,* and *Db* move backwards or forwards they keep the fans or paddles in a direct motion. When these three wheels *Da, D,* and *Db* move forward then the rope *Fb* must move the wheel *Hb* forward, and so cause the paddles to revolve in the same direction. So also the rope *Fa* connects the wheel *Ha* to *Da*, and when the latter and its two sister wheels revolve the wheel *Da*, then the wheel *Ha* draws the rope *F* and raises the weight *G* (barely decipherable in the sketch to the left of *Da*), at the same time as the wheel *Hb* brings the paddles forward.

Furthermore, when the weight *G* is raised while the wheels *Da, D* and *Db* are moving backwards, the rope *Fa* gives way and the power of the weight *G* brings the wheel *Ha* forward and the paddles with it: so that the latter always keep going forward, notwithstanding that the three wheels *Da, D,* and *Db* move backwards and forwards as the piston moves up and down in the cylinder. *LL*—scarcely recognisable owing to the reduction of the sketch—indicate the teeth for a catch to drop in from the axis, and are so contrived that they catch in an alternate manner to cause the paddles to move always forward, for the wheel *Ha*, by the power of the weight *G*, is performing its work while the other wheel *Hb* goes back in order to fetch another stroke. Hulls explains that the weight *G* must contain but half the weight of the pillar of air pressure on the piston, because the weight *G* is raised at the same time as the wheel *Hb* is doing its duty, so that in effect there are really two machines acting alternately by the weight of one

pillar of air of such a diameter as is the diameter of the cylinder.

Hulls expressed another crude idea for when the ship was navigating "up in-land Rivers" and the bottom could be reached. The paddles were then to be removed and "cranks placed at the hindmost Axis to strike a Shaft to the bottom of the River, which will drive the Vessel forward with greater Force."

Daniel Bernoulli, in the year 1753, proved on paper that it was mathematically possible to use a steam engine for propelling ships, the medium being also wheels with vanes attached. There were not wanting other theories and experiments also in the eighteenth century which attained little or no success, their defects arising sometimes through lack of sufficient power to go against a stream, or through some erroneous principle. Of these we might mention especially the experiment made in France by Périer, who, after devoting careful consideration to the problem of the amount of power required, and, after reckoning the necessary force likely to be essential, by the number of horses which were required for drawing along a boat from the towing-path, set to work in his own manner. It happened that in the year 1775, to which we are now referring, there was on view in Paris a unique engine which the now famous and ever memorable James Watt had made. This aroused so much interest that it was decided to hire a boat on the Seine and place therein a Watt machine of one horse-power. Périer carried out his experiment, though owing to the force of the current of the Seine, and the too limited horse-power which the engine was capable of producing, the result was a failure. But one of Périer's associates, the Marquis de Jouffroy, had also been excited by the advent

of this English engine which was an improvement on anything that the world had yet seen, and he resolved to try for himself to find some means of making a ship to go against swift-running rivers independent of horse-towage. In spite of the prejudice which was likely to be aroused in case he should prove successful (for the owners of the monopoly of the more primitive form of inland water transport would not quietly consent to see their living taken away from them), he set forth with considerable courage and an heroic determination. Since it is doubtful whether these interesting experiments would ever have been made had it not been for the happy coincidence of Watt's engine becoming known when it did, it is only right that we should first see something of the circumstances which combined to bring the Englishman's work into such prominence, and then return to follow de Jouffroy in his efforts.

To James Watt, notwithstanding that his work and ingenuity were expended for the purpose of land engines, belongs the honour of having removed the most harassing obstacles which were delaying the full and entire possibility of the marine steam engine. In the chain of discoveries which leads back into early times, without whose cumulative effect he himself would not have done what he did, James Watt comes immediately next to Thomas Newcomen. Despised in his weak, delicate boyhood by his companions, his is another instance of the stone which the builders rejected becoming the head corner-stone. Or, to put the proposition in another way, Watt absorbed all the existing good that there was in the latest engineering knowledge, and advanced that several steps further until it reached the goal of practicability.

In the Newcomen engine there were several notable defects

which marred its usefulness, and it was not until these could be improved upon that there could possibly be a future for the steamboat. This type of "machine" was not closely enough related to the work which it was called upon to perform. Its pre-eminent fault lay in the fact that the condensation took place in the cylinder. This meant a considerable waste, for after the latter had been made cool by the admission of the cold water for condensing the steam, the cylinder had to be heated again before every upward stroke. Heat, in fact, was literally thrown away. It was in the year 1764 that Watt, while endeavouring to repair a model of one of these Newcomen engines and to remedy its poor performance, was struck by the inadequacy of its mechanism and realised that some means should be found to ensure a greater economy of steam. From his ingenious brain, therefore, came an improvement. He provided for the condensation to take place not in the cylinder but in a separate condenser, in which a jet of water was to spray, and finally the condensed steam, the injected water, and the air which had also found its way in, were to be drawn off by means of an air-pump. After a delay of several years Watt was introduced to Matthew Boulton, founder of the Soho Engineering Works, near Birmingham, and in 1769 Watt's invention, embodying the principle of the separate condenser, was patented. Although he had worked out his idea as far back as the year 1765, it was not till four years after that he had the means to secure its protection. In the specification for his patent Watt enunciated what is appreciated as an essential doctrine to-day, that the walls of the cylinder should be maintained at the same heat as the steam which was about to enter into the cylinder. And he proposed to bring about this improvement by adding an

external casing to the cylinder, leaving a space between the casing and the outside of the cylinder itself and keeping always in this space steam so as to preserve a high temperature.

But, as was mentioned on a previous page, the steam engine at this date was not developed with a view to transport, but for the convenience of pumping up water from mines. As a result of Watt's success a considerable demand arose among Cornish mine-owners for these engines made by Boulton and Watt, who were now working in partnership together. For the work of pumping, these machines continued to serve admirably, so long as a vertical up-and-down motion was required. At length Watt turned his mind to some method of obtaining rotary movement from his engine, but in a manner different from that in which Hulls had attempted to attain his end. Watt had covered in the top of his cylinder to keep out the cooling effect of the air, and his well-known beam pumping engine was an improvement on Newcomen's, owing to the simple fact that in economising steam it halved the cost of fuel, and not even to-day are these old-fashioned engines in disuse. As we shall see later on, the beam engine is very much in evidence in some of the river steamships of the United States, apart altogether from those beam engines which are still worked for pumping in some parts of our own country.

With such satisfactory results to encourage him it was inevitable that sooner or later so brilliant a schemer would think out some means for rotary movement, and Watt's first intention was to cause the beam (which was pushed up by the rod joining the piston) to drive a fly-wheel by introducing a crank in something of the same manner in which nowadays the crank of a bicycle drives round the cog-wheel, the cyclist's leg being, so to speak, the connecting rod which joins the

beam. But before Watt had a chance of getting legal protection for this method his secret was stolen by one of his workmen, named Pickard, who revealed it to a Bristol man of the name of Wasbrough, who was also in search of some method of obtaining rotary motion. The latter, therefore, having in 1780 obtained his patent by stealth, Watt was compelled to cast about for some other means of attaining the same end: but his fertile mind soon gave forth what was required, and in the following year he patented what is known as the "sun-and-planet" gear, which converted the vertical movement into a rotary. Put in a few words, the working of the engine was as follows: At the top was the straight beam of wood; from one side of this there hung vertically a rod which connected with the piston in the cylinder, and was thus made to go up and down as in the Newcomen engine. It will be remembered that in Newcomen's machine, at the opposite end of the beam was the other rod for pumping the water. Now in Watt's rotary engine the piston-rod was moved up and down as before, but the opposite rod, at the other end of the beam, was connected with a spur-wheel having cogs in it. There was also a large fly-wheel which had a similar cog-wheel on its shaft, and thus, as the piston rod pushed up its end of the beam the opposite end of the beam was lowered and its rod also. But through the arrangement of the two cog-wheels the connecting rod caused the fly-wheel to revolve, and at twice the rate at which it would have gone round had Watt's original rod and crank idea been employed, for the "planet" cog-wheel goes round in a circle but does not revolve on its own axis. Some of his engines of this type were so arranged that the speed of the fly-wheel shaft was not so much greater than in the case where a crank was employed.

Thus, in this important adaptation of the vertical to the rotary movement, we get the nucleus of the future steamboat engine, which was to turn the paddle-wheels round. But Watt did not stop there. We have seen that whilst it was the steam which pushed the piston and its rod upwards, it was yet the pressure of the air and the weight of the parts which caused the piston and rod to descend. Now, as we have seen, Watt had already resolved to cover in the top of the cylinder in order to keep out the air from cooling the latter. It was, then, but a natural transition to utilise the steam not merely for pushing the piston upwards, but also for sending the same down after its ascent had been made. We thus get what is the well-known double-action of the modern reciprocating engine, in which steam is employed from either side of the piston alternatively, so that each stroke becomes a working stroke and the power of the engine is doubled. It was Watt who, as early as the year 1782, discovered the advantages which were possessed by the expanditure of steam, but as this does not enter into practical application just yet, we can postpone the subject to a later chapter. We need only emphasise the fact that the fly-wheel which is so familiar to all of us was the invention of Watt, and it is perhaps scarcely necessary to explain that the reason for the existence of this wheel is in order that it may, at the beginning of the stroke, when the engine is at its strongest, store up the surplus energy and give it back towards the end of the stroke. It thus maintains an equal motion throughout the whole stroke given forth by the piston and its rod.

The earliest marine steam engines were very much on these lines, then, and were really a slightly modified form of land engine. But, as we shall soon come to refer to the

more complicated type of engine, and to make use of other terms, it may not be out of place here to deal at once with the expression "horse-power," which is used for the purpose of indicating the force which an engine is capable of developing. The origin of this expression is not without interest, and Sir Frederick Bramwell, Bart., F.R.S., D.C.L., in his entertaining article on the life of Watt in the "Dictionary of National Biography," points out that Savery, to whom we have referred, was accustomed to calculate that where any machinery had to be driven by means of a single horse, it would entail a stock of three of these animals being kept, so that one should be able always to be at work. Thus supposing that the power exerted by six horses was necessary to drive a pump, and Savery made an engine capable of doing the same work by mechanical means, he would call it not a six horse-power engine, but an eighteen horse-power. Watt, however, did not credit his engine with the idle horses. He satisfied himself that an average horse could continue working for several hours when exerting himself so as to raise one hundredweight to a height of 196 feet in one minute, which is about equal to lifting 22,000 pounds one foot high in the same time, as the reader will find by simple arithmetic. But in order that no purchaser of his engines should have any ground for complaint, Watt went one step better, and determined that each horse-power of his engine should be capable of raising to a height of one foot, in one minute, not 22,000 pounds, but 33,000 pounds, or half as much again. And so to-day when we speak of an engine possessing such and such horse-power we still mean that it is equivalent to such a power as would raise 33,000 foot-pounds per minute. I make no apology for dwelling to such an extent on this point, but since at least

one writer on steamships has seen fit to refer to this assessment of horse-power as being entirely arbitrary, and to admit in the same paragraph that he was altogether ignorant as to what power a horse was actually capable of producing, I have thought it not inappropriate to make the point clear in the mind of the reader.

Let us now cross the Channel again to France, and remembering that Watt had patented his engine in 1769 and that Périer, after seeing one of the Englishman's engines, had installed one in his boat on the Seine in 1775, and failed in his experiment, let us see the attempts at steamboat navigation continued by the Marquis de Jouffroy. Here again writers have cast some doubt on the achievements accomplished by this distinguished Frenchman, but if we turn to an interesting little book entitled "Une Découverte en Franche-Comté au XVIIIe siècle. Application de la vapeur à la navigation," by Le Mis. Sylvestre de Jouffroy D'Abbans (Besançon, 1881), we shall find the facts verified. Briefly, the story is that in 1776 the Marquis, undismayed by Périer's failure, obtained a Watt engine suitable for his boat, which was only 13 metres long, and in width 1 metre 91 centimetres, so that she was quite a small craft. She was propelled by steam, the revolving blades being 2 metres 60 centimetres in length and suspended on each side of the ship near the bows. The engine was placed in the middle of the boat and worked the revolving blades by means of chains. This experiment took place at Baume-les-Dames, though it does not appear to have contributed much to the ultimate success of steam navigation. But in 1781 this same François Dorothée, Comte de Jouffroy D'Abbans, made a much bolder essay and built a far larger steamboat, which measured 46 metres long, 5 metres wide,

THE MARQUIS DE JOUFFROY'S STEAMBOAT.

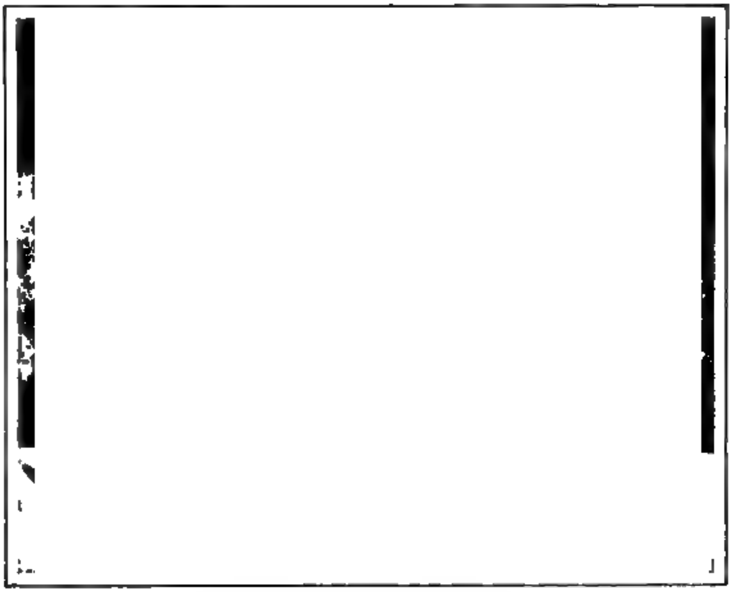
From Mr. R. Prosser's Pen-and-Ink Sketch in the Victoria and Albert Museum, South Kensington.

and had a draught of 1 metre. This steamship was tried at Lyons on the Saône on July 15, 1783, not 1781 nor 1782, as some writers have asserted. Her success was undoubted, for she went against the stream from Lyons to the Isle of Barbe several times, not in any secret manner, but in the presence of 10,000 witnesses. There is no possible doubt, for the interesting event was duly attested and, I believe, this declaration exists still in Paris. The illustration here given has been photographed from the pen-and-ink sketch which was copied in the year 1880 by Mr. R. Prosser from a French print that was published in 1816, and was alleged to represent this steamboat to which we are referring. But this illustration, from the fact that it was issued so many years after the occurrence, and also that it differs in some details as given by French writers, should be regarded with caution. It shows a boat whose paddle-wheels are turned by a single horizontal steam cylinder, the piston-rod engaging the shaft of the paddle-wheels by means of a ratchet arrangement which will be easily recognised. But it is also affirmed that Jouffroy's vessel of 1783 had two cylinders, that the piston of each of these was connected with an iron flexible chain, and that these revolved the paddle-wheels. The latter were 14 feet in diameter and the paddle-boards themselves were 6 feet wide. The two cylinders were placed behind each other and communicated with each other by means of a wide tube. The French Revolution followed, in 1789, when the Marquis de Jouffroy, in order to save his life, had to go into exile for some time, and on his return, ere he was able to obtain a patent for his achievement, someone else had stepped in and forestalled him.

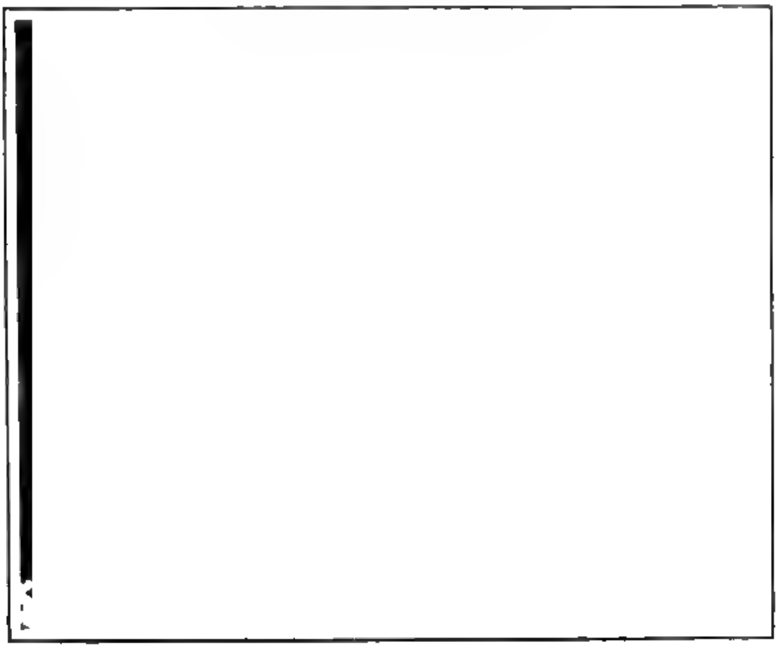
In the meantime, in England, something more practicable than Hulls' efforts had brought about was to be witnessed.

If the reader will examine the illustration facing this page he will see a model of a curious double-hulled ship, which was one of eight or more paddle-propelled vessels that were employed in the experiments carried out by Patrick Miller, a wealthy Edinburgh banker. This particular vessel was built at Leith in 1787, and it is amusing to see in her that old idea of physical propulsion brought forward once more. Between the two hulls sufficient space was left for the insertion of five paddle-wheels, 7 feet in diameter, immediately behind each other, which were driven by thirty men, heaving away at the capstan placed on deck. We find pretty much the same speed to be obtained as in the experiments which we have mentioned in connection with other craft thus propelled, for the best effort when all these hands were working to get her through the water appears to have been under 4½ knots per hour. In our illustration she is seen with masts and sails which she used when the paddle-wheels were lifted out of the water and placed on deck. It will be noticed that she was steered by a couple of rudders; her displacement was 255 tons. This probably represents the final development of Miller's design using muscular power, but an earlier and smaller ship belonging to the previous year carried only two paddle-wheels, 6 feet in diameter and 4 feet wide, which were placed on each side of the middle hull, for this ship was not double- but triple-hulled.

After spending some time in making these experiments and realising the enormous amount of muscular power which was needed, it was suggested to Miller by James Taylor, who was tutor to his children and a personal friend of William Symington, of Wanlockhead, that it would be far preferable to employ steam power to drive the paddle-wheels; and the



PATRICK MILLER'S DOUBLE-HULLED PADDLE-BOAT.
From the Model in the Victoria and Albert Museum.



SYMINGTON'S FIRST MARINE ENGINE.
From the Model in the Victoria and Albert Museum.

upshot was that Symington was commissioned to design a suitable engine, which in October of 1788 was placed on one deck of a double-hulled pleasure craft 25 feet long and 7 feet wide, whilst the boiler was placed on the other deck. Thus fitted, the strange little ship was tried on Dalswinton Loch, Dumfriesshire, when she exhibited a speed of five knots per hour, and afterwards seven knots. At the first attempt the boards of the paddle-wheels were broken by concussion. Symington's engine, however, was really of the atmospheric pattern, with the addition of a separate condenser, and was an infringement of Watt's patent. After but a few trials the experiments accordingly had to be abandoned, although Miller afterwards got into communication with Boulton and Watt, whom he endeavoured to interest in steam navigation, but they declined.

Miller next bought one of the boats used on the Forth and Clyde Canal, and gave an order to the Carron Iron Works to make a steam engine in accordance with Symington's plan. On December 26, 1789, this vessel towed a heavy load seven miles an hour, but was afterwards dismantled.

Symington's first engine is shown in the illustration facing page 42, which is taken from a model in the South Kensington Museum, the original being in the Andersonian Museum, Glasgow, and it will be useful for reference in case our description of Newcomen's engine was lacking in clearness. As will be noticed, there are two cylinders, each being open at the top, and a piston working up and down inside. It will be seen, too, that there are two paddle-wheels; these were placed in the ship fore and aft between the two hulls, and not on either side as in our modern paddle-wheel steamers. There were eight floats in each wheel, which were not

feathering, but fixed. Each piston was connected with a drum by means of chains, the latter turning the drums alternately in opposite directions, and power was obtained both from the upward and downward strokes. By means of a ratchet arrangement, alternately engaging with pawls, the paddle-wheel was made always to revolve in one direction. The engine was fitted with air pumps for the purpose of which we have already dealt. In many ways it will be seen that Symington's engine and gear resembled the method proposed by Hulls.

But the same subject that was beginning to interest both Frenchmen and Englishmen was also being studied with zest in North America. In November of 1784, at Richmond, Virginia, James Rumsey had succeeded in making some interesting experiments with a model boat propelled by steam power, which boat was seen by George Washington. Rumsey afterwards came over to England, and it is not without interest to remark at this stage that one of the most frequent visitors to him in his new home was that famous Robert Fulton, of whom we shall speak presently. Mr. John H. Morrison, in his "History of American Steam Navigation" (New York, 1903), alludes to John Fitch as the pioneer of American steam navigation, but Fitch is known to have been very jealous of Rumsey, and accused him of "coming pottering around" his Virginian work-bench.

Fitch was the first man in America who successfully made a paddle steamboat to go ahead. The date of this was July 27, 1786, and the incident happened on the River Delaware. According to Fitch's own description of his ship, which was written in the same year as the vessel's trial, she was just a small skiff with paddles placed at the sides and

revolved by cranks worked by a steam engine. This latter machine was similar to the recent improved European steam engines—that is to say, Watt's—but the American engine was to some extent modified. It consisted of a horizontal cylinder, in which the steam worked with equal force at either end. Each vibration of the piston gave the axis forty revolutions, and each revolution of the axis caused the twelve oars or paddles to move *perpendicularly*, whose movements, to quote Fitch's own words, "are represented by the stroke of the paddle of the canoe. As six of the paddles [*i.e.*, three

OUTLINE OF FITCH'S FIRST BOAT.

on each side], are raised from the water six more are entered." In 1788, Fitch had another boat ready which was 60 feet long and 8 feet wide, her paddles being placed at the stern and driven by an engine which had a 12-inch cylinder. It was this vessel which steamed from Philadelphia to Burlington, a distance of twenty miles. He also had another craft built in the following year which was first tried in December of 1789 at Philadelphia. This was something more than a mere experiment, for the boat showed a speed of eight miles an hour; she afterwards ran regularly on the Delaware, and during the summer of 1790 covered an aggregate of two or three thousand miles. It is not to be wondered that Fitch

was mightily disappointed at the lack of faith which his shareholders exhibited by retiring one by one, and finally he ended his days by suicide. It would seem, indeed, that in giving praise to Fulton, John Fitch has not always been credited with his full deserts. Of his predecessors it may be said generally that they had succeeded not so much as a whole, but in regard to overcoming certain obstacles, and continuous actions were being fought out in the American Courts for some years which engaged Fulton until the time of his death. It was not until the Supreme Court of the United States in 1824 decided adversely to Fulton's associates on the question of exclusive right to steamboat navigation on the Hudson that this new industry received its impetus and a large number of steamships began to be built. But we are anticipating and must return to the thread of our story.

In Scotland, which has been not inaccurately called the cradle of the world's steamship enterprise, another interesting experiment was to be witnessed early in 1802, where a vessel named the *Charlotte Dundas* (of which an interesting model, now in the South Kensington Museum, is here illustrated) was to cause some pleasant surprise. This vessel was 56 feet long and 18 feet wide ; she had a depth of 8 feet. As will be seen from the illustration, she was fitted with a paddle-wheel placed inside the hull, but at the stern. Her horizontal engine was also by Symington, and since most of the mechanism was placed on deck, we are able to see from the model a good deal of its working. It will be noticed that the cylinder is placed abaft of the mast and that the piston-rod moved on guides which can be just discerned in the photograph. Attached to this is the connecting rod, which terminates at the crank on the paddle shaft, an entirely different means

THE "CHARLOTTE DUNDAS."

From the Model in the Victoria and Albert Museum

THE "CLERMONT" IN 1807.

From a Contemporary Drawing in the Victoria and Albert Museum

of obtaining rotary motion as compared with the "sun-and-planet" method which we saw adopted by Watt. As the steam entered the cylinder from the boiler it pushed the piston and its rod horizontally; and the connecting rod, being attached thereto at one end, and to the crank at the other, the paddle-wheel was made to revolve. Below the deck were the boiler, the condenser and the air-pump. The two rudders were controlled by means of the capstan-like wheel seen in the bows. As here seen the paddle-wheel is open in order to show its character, but as considerable spray would be cast up on deck when the wheel was revolving it was covered over by the semi-circular box, which is seen on the ground at the left of the picture. This engine which Symington supplied to the *Charlotte Dundas* was of a kind different from that which he had previously fitted to Miller's double-hulled ship. For by his own patent Symington superseded the old beam engine, and obtained his rotary motion by coupling the piston-rod, by means of a connecting rod, with the crank.

This little craft is deserving of more than momentary interest, for she marked an important advance and considerably moulded the ideas of subsequent steamship inventors or adapters. Hers was the first horizontal direct-acting engine which was ever made, at any rate in this country, and in her simple mechanism may be easily recognised the nucleus of the engines in the modern paddle-wheel excursion steamer. She was built for Lord Dundas in 1801 as a steam tug-boat to ply on the Forth and Clyde Canal. The year after she was completed she towed for nearly twenty miles at a rate of 3½ miles per hour two 70-ton vessels loaded, but just as bad luck had followed the efforts of Papin, de Jouffroy and other steamboat pioneers, so it was to be with the *Charlotte Dundas*.

Although she had so splendidly demonstrated her usefulness, yet the wash from her paddle-wheel was such that the owners of the canal feared for the serious amount of injury which might be done to the canal-banks, and so the *Charlotte Dundas* was laid up in a creek of the canal, and rotted out her years until one day she was removed and buried in Grangemouth Harbour. But we may look upon her with great respect as being one of the parents of those two notable steamboats which were to follow and set the seal of success finally on the steamship proposition. I refer, of course, to the *Clermont* and the *Comet*.

And so we come to the name of Robert Fulton, whose praises have recently been sung so loudly by his appreciative fellow-countrymen. Born in the year 1765 at Little Britain, Pennsylvania, of Irish descent, he left America in 1786 and came to England, whence in 1797* he crossed over to France, where he devoted himself assiduously to the production of various inventions, which included, amongst others, a submarine craft called a "plunging boat." Fulton's "good fairy" was a fellow-countryman whom duties of office had also sent to settle in Paris. This Robert R. Livingston was born in New York City in the year 1746, and died in 1818. A distinguished American politician and statesman, he was appointed in 1801 as the United States Minister to France. It happened that in his private capacity Chancellor Livingston was keenly interested in mechanical matters, and the experiments of Fitch and Rumsey had attracted his attention to the question of steamboats. By an Act passed in 1798, Livingston had been granted the exclusive right of navigating all kinds of boats that were propelled by the force of fire or

* Mr. G. Raymond Fulton, the inventor's great grandson, however, gives the date as 1796.

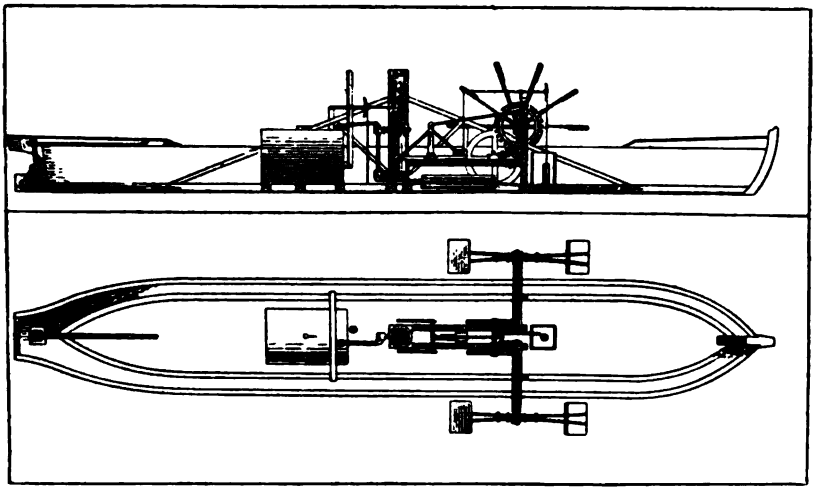
steam on all waters within the territory or jurisdiction of the State of New York, for a term of twenty years, on condition that within the ensuing twelve months he should produce such a boat as would go at a pace of not less than four miles per hour. Thereupon Livingston immediately had a 30-tonner built, but her performance was disappointing, for she failed to come up to the four-mile standard. It was soon after this that he crossed to France and there came into contact with young Fulton. To quote Livingston's own words, which he used in describing the account of their business partnership, "they formed that friendship and connexion with each other, to which a similarity of pursuits generally gives birth."

The American Minister pointed out to Fulton the importance which steamboats might one day occupy, informed him of what had so far been accomplished in America, and advised him to turn his mind to the subject. As a result a legal form of agreement was drawn up between them, signed on October 10, 1802, and forthwith they embarked on their enterprise, Fulton being allowed a fairly free hand in the preliminary experiments which "would enable them to determine how far, in spite of former failures, the object was attainable." Fulton had a considerable knowledge of mechanics, both theoretical and practical, and after trying various experiments on models of his own invention he believed that he had evolved the right principles on which the steamboat should be built. Some of these experiments were carried on in the house of another fellow-countryman, Joel Barlow, then sojourning in Paris. A model 4 feet long and 1 foot wide was used to ascertain the best method to be employed: whether by paddles, sculls, endless chains or water-wheels, the power being obtained temporarily by means of clockwork. Finally, he decided on

having one wheel at either side, but in order to convince themselves that what was true of a small model might also be demonstrated in bigger craft, the two partners decided to build a boat 70 French feet long, 8 French feet wide, and 3 French feet deep. Fulton states that they hired from M. Périer a steam engine "of about 8 horses power." There were two brothers of this name, and one of them had already made an essay in the sphere of steam navigation, as we have noted. Whether or not this borrowed engine was of the Watt type I am not able to say, but since Périer had already possessed one, and Fulton during the same summer in which his experiment on the Seine took place got into communication with Messrs. Boulton and Watt with a view of purchasing one of their engines, it is by no means improbable that this was of English make. On either side of the craft was placed a paddle- or, as Fulton described it, a "water-" wheel, having a diameter of about 12 feet. In an interesting article in *The Century Magazine* for September and October of 1909, Mrs. Sutcliffe, a great-granddaughter of Fulton, gathered together a number of facts which have hitherto remained hidden away from the eyes of the public, and published for the first time a complete description of her ancestor's trial boat, taken from a document prepared by Fulton eight years after the vessel was ready for her experiment. In this statement Fulton strangely enough remarks that the power from the engine was communicated to the water-wheels "by mechanical combinations which I do not recollect," but the drawing shown on page 51 will clear up this point. The arrangement of the boiler, the cylinder, and the working parts sufficiently shows those "mechanical combinations" which had slipped from Fulton's memory during the following eventful and industrious years.

This boat which was used on the Seine was 70 feet long, 8 feet wide, and drew very little water.

In January of 1803 Fulton, who had already been attracting some attention in his adopted country by his submarine experiments, decided to offer his steamboat to the French Government and a Commission was appointed to inquire into its merits. The illustration on this page is taken from Fulton's



FULTON'S DESIGN FOR A STEAMBOAT SUBMITTED TO THE COMMISSION APPOINTED BY NAPOLEON IN 1803.

From the Original Drawing in the Conservatoire des Arts et Métiers, Paris.

own drawing of his projected steamboat submitted to this Commission appointed by Napoleon, the original of which is now preserved in the Conservatoire des Arts et Métiers, in Paris. In his letter to the Commissioners, Fulton observes that his original object in making this experiment was rather with a view to the employment of steam tow-boats for use upon the rivers of America, "where there are no roads suitable for hauling," and "the cost of navigation by the aid of steam

would be put in comparison with the labour of men and not with that of horses as in France." In fact, he suggests that if his experiment should prove successful, it would be infinitely less useful to France than to his native country, for he doubts very much if a steamboat, however perfect it might be, would be able to gain anything over horses for merchandise, "but for passengers it is possible to gain something because of the speed." Ultimately Napoleon's advisers counselled against the adoption of Fulton's proposition.

However, by the spring of 1808, the boat was completed and lying on the Seine in readiness for her trial trip. Fulton spent a restless night, and we can well picture the feelings of the man who had wrestled with calculations, worked out theories, made little models, watched their behaviour in still water, spent hours and days discussing the subject with his friend Livingston, thought out every conceivable aspect, allowed for obstacles, and now, at length, after watching the child of his brain gradually take a concrete shape, waiting sleeplessly for the morrow in which he was to have the chance of living the great day of his life. Those of us who remember ever to have looked forward with zest and suppressed excitement to some new event in our lives likely to alter the trend of future years can well sympathise with the emotions of this clever young inventor, when, whilst eating his breakfast, a messenger burst in and dramatically exclaimed to his horror: "Please, sir, the boat has broken in two and gone to the bottom!"

It was suggested in our introduction that it is usually the case that an invention is no sooner born than it is compelled, while yet frail and infantile, to fight for its very existence: and it is curious that this should seem to be demanded not

merely as against the opposition of human obstinacy but against sheer bad luck, which comes as a test of a man's sincerity and of his faith in his own ideas. In the end, historically, this calamity had no ill-effects, for it only spurred the enthusiast to greater and more perfect accomplishment. But physically it cut short Fulton's life of usefulness. As soon as the heart-breaking news was delivered to him, he rushed off to the Seine and found that the intelligence was all too true. For the next twenty-four hours he laboured assiduously, not stopping for food or rest, ignoring the chilly waters of the river, until his precious craft was raised from its watery bed. Fulton never recovered entirely from these physical trials following so suddenly on his years of mental work and worry, and his lungs were permanently affected for the rest of his life. But what he did recover—and that no doubt was to him more precious than his very life—were the machinery and main fragments of the hull. The gale of the night before had done more than wreck his ship: it had taught him to allow for one difficulty which he had overlooked, and it was well that it had happened thus instead of later on, when loss of life might have prejudiced the coming of the steamboat even longer still.

For Fulton soon realised that he had made his hull insufficiently strong for the weight of the machinery. This is the truth of the incident, and not that jealous enemies had maliciously sunk her, nor that Fulton had himself sent her to the bottom through the lack of appreciation which Napoleon's Commissioners were exhibiting. This is confirmed by an eyewitness of the event, named Edward Church. But Fulton soon set to work to get his ship built more strongly, and by July of the same year she was ready for her trials. A

contemporary account, in describing the strange sight which was witnessed on August 9, 1803, says that at six o'clock in the evening, "aided by only three persons," the boat was set in motion, "with two other boats attached behind it, and for an hour and a half he [Fulton] produced the curious spectacle of a boat moved by wheels, like a chariot, these wheels being provided with paddles or flat plates, and being moved by a fire-engine." The same account prophesies great things for the invention and that it will confer great benefits on French internal navigation: for, by this means, whereas it then required four months for barges to be towed from Nantes to Paris, the new method would cause them to do the distance in ten or fifteen days. Very quaintly this account speaks of the existence behind the paddle-wheels of "a kind of large stove with a pipe, as if there were some kind of a small fire-engine intended to operate the wheels of the boat!"

These experiments were made in the vicinity of the Chaillot Quay in the presence of many people, including Périer and some of the leading Parisian *savants*, and the boat was found to steam at a rate of 3½ miles per hour. It is therefore both inaccurate and unjust to dismiss, as at least one writer has done, Fulton's achievements on the Seine in one line by referring to them as unsuccessful and merely experimental. True, this vessel did not show that amount of speed which Fulton had hoped to get out of her, but she was very far from being a failure. Fulton had left nothing to chance, and the misfortune of the weakness of his first hull and the error in the speed actually obtained were the results rather of inexperience than of carelessness. It is difficult to-day, when we are in possession of so much valuable knowledge connected with naval architecture and marine propulsion, to realise that

these early experimenters were feeling in the dark for an object they had never seen. At one time Fulton had estimated that a steamboat could be driven at a rate of sixteen to twenty-four miles an hour, but he found that so much power was lost in getting a purchase on the water that he altered his opinion and put forward the speed of five or six miles as the utmost limit which could be obtained by any boat using the best engines then in existence.

Fulton had advanced with almost meticulous caution. He had first collected together all the details that could be got about contemporary experiments; he had sifted the theories of others and made use of the residue. He had often talked with Rumsey while in England, and he had even accompanied Henry Bell to call on Symington, seen a trial trip of the *Charlotte Dundas*, and incidentally obtained some valuable information. Finally, after seeing what was good and what was bad he had proceeded independently, and, after a stroke of ill-luck, succeeded. He had knowledge of what others had attempted in America, in England and in France, and emphatically he was not the kind of man to deny his indebtedness to what others had done before him. The ship which he evolved was certainly in shape, proportions and general appearance not unlike the model of that earlier craft whose exploits on the Saône we considered on another page. The Marquis de Jouffroy had sent this model to Paris as far back as 1783, the year of his successful enterprise at Lyons, or twenty years before Fulton made his achievement, and it is most improbable that Fulton, who endeavoured to see everything which bore on his pet subject, living several years in Paris, should not have carefully studied this. Furthermore, Fulton's boat was constructed in the workshop and under the very

eyes of that Périer who had been associated with the Marquis in navigating the Seine by steamboat, and from this same Périer, as already stated, the engine was borrowed for Fulton's boat. Fulton also personally considered the patent which Desblanc, forestalling Jouffroy, had obtained, and the American had described his impressions of Desblanc's idea in no praiseworthy terms, for he saw that at least two-thirds of the latter's steam power would be lost. Fulton worked his plans out to the minutest details: Desblanc had left his theory too scantily clothed with facts. He had not found the proportion which his paddles should bear to the bow of his boat, nor the velocity at which they should run in proportion to the velocity at which the boat was intended to go. Very scathing is the American's denunciation of this haphazard method. "For this invention to be rendered useful," wrote Fulton, "does not consist in putting oars, paddles, wheels or resisting chains in motion by a steam engine—but it consists in showing in a clear and distinct manner that it is desired to drive a boat precisely any given number of miles an hour—what must be the size of the cylinder and velocity of the piston? All these things being governed by the laws of Nature, the real Invention is to find them."

Fulton believed that previous failures were due not so much to a defective steam engine, as to the wrong methods employed in applying the steam power thus generated. He criticised Rumsey's method of propelling a ship by forcing water through the stern (in a manner similar to that which John Allen and Fitch had suggested) as the worst method of all. Ten years before his Seine success Fulton had been in communication with the Earl of Stanhope, who in 1790 had patented a means of propelling a ship in a strange way. This

consisted in using a gigantic arrangement resembling a duck's foot, placed on either side. These feet opened and shut like umbrellas and could send the ship along at three miles an hour. Fulton, then staying at Torquay, wrote to Lord Stanhope

FULTON'S FIRST PLANS FOR STEAM NAVIGATION
From the Drawings in possession of the Rt. Hon. the Earl of Stanhope.

and proposed the use of paddle-wheels, but the noble earl would not listen to the suggestion. A similar freak idea was also put into practice in North America in 1792 by one Elijah Ormsbee.

The illustrations on this page represent Fulton's first plans

for steam navigation. They were sent by him to Lord Stanhope in the year 1793 and are here reproduced from a copy, by kind permission of the present earl. In his letter descriptive of these ideas Fulton shows the upper part of this illustration, marked No. 1, to be an attempt to imitate the spring in the tail of a salmon. Amidships will be noticed an object resembling a bow such as one usually associates with arrows. This bow was to be wound up by the steam engine, and the collected force attached to the end of the paddle, shown in the stern of the boat, would urge the ship ahead. But the sketch of a ship in the lower part of the picture marked No. 2 represents the model at which he was then working. It will be noticed that she has something of the characteristic stern which was so marked a feature of the sailing ships of this period and had been inherited from the Dutch of the seventeenth century, and is still traceable in the design of the modern royal steam yachts in England, as will be seen by a comparison with the illustration of the *Alexandra*. In referring to this No. 2, Fulton points out that he had found that three or six paddles answered better than any other number, since they do not counteract each other. By being hung a little above the water there is allowed a short space from the delivery of one paddle to the entrance of the other, and, also, the paddle enters the water more perpendicularly; the dotted lines show its situation when it enters and when it is covered. In the smaller illustration, No. 3, he emphasises the importance of arranging the paddle-blades still further. Thus the paddles *A*, *B*, *C*, and *D* strike the water almost flat and rise in the same situation, whilst that paddle marked *E* is the only one that pulls, the others acting against it. Whilst *E* is sending the ship ahead, "*B.A.* is pressing her into the water and *C.D.* is pulling her out, but

remove all the paddles except *E* and she moves on in a direct line." Finally, he concludes his letter with an explanation that the perpendicular triangular paddles are supposed to be placed in a cast-iron wheel "which should ever hang above the water" and would answer as a "fly and brace to the perpendicular oars"; and with regard to the design of the steamship, he says: "I have been of opinion that they should be long, narrow and flat at bottom, with a broad keel as a flat Vessel will not occupy so much space in the water: it consequently has not so much resistance."

Desblanc had, like the Earl of Stanhope and Elijah Ormsbee, experimented with the duck's foot idea, but had also met with failure. Fulton carefully went into the consideration of its merits before trying his Seine boat, but deemed it to be unsuitable. Whatever advantages this method might have possessed, the action of the duck's foot caused far too great resistance, since after making the propelling stroke it returned through the water before being ready for the following stroke; whereas in the case of the revolving paddles or oars on wheels their return is made through air. Thus the resistance is considerably less.

But all this time Fulton had his native country in mind and not so much the advantages that might accrue to the land in which he had made his experiments. It was the Hudson, not the Seine, which he longed to conquer by steam, and the title-page of his note-book, dated more than a year prior to the events on the Seine, in which he drew a prophetical sketch of a steamboat travelling from New York to Albany in twelve hours, eminently confirms this. Therefore, we find him immediately writing to Messrs. Boulton and Watt from Paris, asking them to make for him "a cylinder of 24 horse-power

double effect, the piston making a four-foot stroke"; also he wants them to manufacture a piston and piston-rod, valves, condenser, air-pump, and so on. It is perfectly clear that Fulton had but limited knowledge of the amount of power which an engine could develop. His ability consisted rather in knowing how best to apply that power. Thus he asks in his letter: "What must be the size of the boiler for such an engine? How much space for water and how much for the steam? How many pounds of coal will such an engine require per hour?" and so on. At first Boulton and Watt had to decline the order, since they were unable to obtain permission to get the engine into America. Finally, after paying £548 in purchase, it was not until March of 1805, or most of two years after receiving the order, that Boulton and Watt received permission to ship the engine to America. Fulton had crossed from France to England in 1803, and in the autumn of 1806 left by a Falmouth packet for his native land. Writing to-day, when the *Mauretania* and *Lusitania* are still making their wonderful records for fast voyages between the two countries, little more than a hundred years after Fulton had given the inspiration to marine engineering, it is no small contrast that the ship which carried him from England to America took no less than two months on the way. But the same winter he set to work immediately after his return to build that ever-famous *Clermont*, so called as a courteous acknowledgment of the hospitality he had enjoyed at Livingston's country place of that name on the banks of the Hudson. From an agreement which had already been made in Paris, dated October 10, 1802, between Livingston and himself, Fulton had jointly contracted to make an attempt to build such a steamboat as would be able to navigate the Hudson between New York

and Albany. She was to be of a length not exceeding 120 feet, width 8 feet, and was not to draw more than 15 inches of water. "Such a boat shall be calculated on the experiments already made, with a view to run 8 miles an hour in stagnate water and carry at least 60 passengers allowing 200 pounds weight to each passenger." After the engine had at last arrived in New York it remained for six months at the New York Custom House, waiting, it is said, until Fulton was able to raise enough money to pay the duties. But as Mrs. Sutcliffe has pointed out in her article on Fulton to which reference has already been made, and to which also I am indebted for many interesting facts then for the first time made public, it is possible that the delay arose because the boat was not yet ready to receive her machinery. Fulton had rich friends who were interested in his work, so that I think the latter is the more probable reason for the delay.

And here, as we step from out of the realm of theories and suggestions into a realm of almost uninterrupted success, we may bring this chapter to a close. But before doing so let us not lose sight of that important fact on which I have already insisted—viz. that when steamboat success did eventually come, it was the happy fortune of no single individual, but an achievement in which many men, long since dead and gone, took part. It was the work of centuries and not of a year or two to bring about this marvellous means of transport. Hero, the ancient Romans, Blasco de Garray, Besson, Solomon de Caus, the Marquis of Worcester, Papin, Savery, Hulls, Watt, Périer, de Jouffroy, Miller, Symington, Taylor, Fitch, Stanhope, Desblanc, Livingston, Rumsey and others had all assisted in bringing this about, sometimes by their success, sometimes also by their failures. When next

we step aboard even the most ill-found excursion steamer or the grimiest and most antiquated tug-boat, still more when we lie peacefully in the safety and luxury of a great modern liner, let us not forget that none of this would have been possible but for centuries of work and discovery, years of patient experiment and costly efforts, much disappointment, and considerable anxiety and abuse.

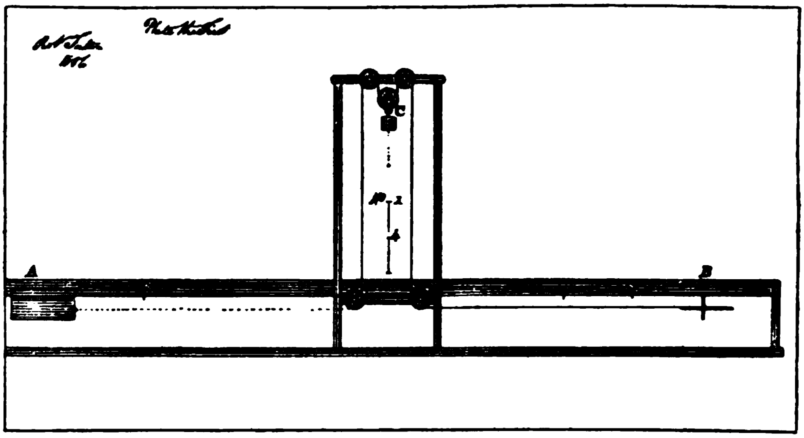
CHAPTER III

THE EARLY PASSENGER STEAMSHIPS

ROBERT FULTON was not the first to attempt steam navigation on the Hudson, and we have already given instances of the experiments made in the New World; but between the time of his success in Paris and his return to America, although others had failed before, experiments still went on. Thus, in the year 1804, John Stevens, whose interest in the steam propulsion of ships had been aroused by watching Fitch's endeavours, decided to see what he could do. So by the month of May he had constructed a steamboat which succeeded in crossing the Hudson from Hoboken to New York, being propelled by a wheel placed at the stern, driven by a rotary engine. In the same month also Robert L. Stevens crossed from the Battery, New York, to Hoboken in a steamboat fitted with tubular boilers, which were the first of their kind ever to be made. The machinery was designed by Stevens himself in his own workshop, and it is important to add that this vessel was propelled not by a paddle-wheel but by a double screw, five feet in diameter, with four blades set at an angle of 35°.

Thus it was that three years before Fulton's *Clermont* came on to the scene with her paddle-wheels, Stevens had already shown the way with screws. But this success was rather momentary than permanent: a mere flash, though startling in its brilliancy. Immediately after his return to America, Fulton had set to work to build the *Clermont*, having

to endure in the meanwhile the scoffings and even threats of the incredulous, which necessitated the ship being protected night and day before she was quite ready for service. In addition to the main parts of the engines which had arrived from Boulton and Watt, there was much to be done before the combination of hull and parts could produce a steamboat. In the meantime funds had been drained somewhat extensively,



FULTON'S DESIGN OF ORIGINAL APPARATUS FOR DETERMINING THE RESISTANCE OF PADDLES FOR THE PROPULSION OF THE *CLERMONT*. DATED 1806.
From the Original in the possession of the New Jersey Historical Society.

and an offer was made to John Stevens, to whom we have just referred, to come in as a partner. The latter happened to be a brother-in-law of Livingston, Fulton's patron, but the suggestion was declined. In the end the money, amounting to a thousand dollars, was found elsewhere, and the *Clermont* was completed. We know on Fulton's own authority that she measured 150 feet in length, was 18 feet wide, and drew 2 feet of water, so that the original dimensions, as given in the agreement which we mentioned as having been made between

Livingston and Fulton, were exceeded. She displaced 100 tons of water, her bottom being built of yellow pine 1½ inches thick, tongued and grooved, and set together with white lead. The floors at either end were of oak.

Before leaving England in 1806, Fulton had already made a set of drawings embodying his ideas with regard to the forthcoming *Clermont*. And so zealous was he for their safety, that before leaving by the October Falmouth packet he had these carefully placed in a tin cylinder, sealed and left in the care of a General Lyman, with instructions that it was not to be opened unless he went down during the crossing of the Atlantic. But if he reached America safely these were to be sent across to him in one of the vessels leaving about the following April, "when the risk will be inconsiderable." The illustration on page 64 represents "Plate the First," giving Fulton's design of an apparatus for finding the resistance of paddles for the propulsion of the *Clermont*. In this he demonstrated the impropriety of making small paddles for a large boat. Briefly we may explain it by remarking that Fulton was proving that the paddles in the water should present, if possible, more surface than the bow of the boat, and that careful calculation must be reckoned so as to avoid wastage of power by not making due allowance for the resistance of the ship as she goes through the water. In Fulton's time the relation of the water to the moving ship had not been accurately defined, and for that matter has not been finally settled to-day, although, thanks to the patient and valuable experiments of the late Scott Russell, W. Froude and of his son, Dr. Robert Edmund Froude, we have now considerable knowledge on the subject, which has borne practical fruit in the design of the hulls of modern ships. To-day experiments are still going on in

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specially-fitted tanks in different parts of England, America and Germany. At the moment of writing a special launch is being built at Marblehead, U.S.A., for purely experimental purposes under the direction of Professor Peabody, since the conditions which prevail in tanks using small models are not thought to be wholly trustworthy. The problems to be considered will embrace the number of propellers which give the best speed; they will be tried in all sorts of positions, and an endeavour will be made to ascertain the relation of the resistance of the boat to the force generated by the engines inside, and the effectiveness which the combination of hull and boat produce. Every motor-boat owner to-day knows very well that there is a good deal of difference sometimes between the calculations of the theorist in regard to the propeller and the knowledge which comes by actual use.

Many of the readers of this volume will no doubt have often been struck by the enormous rate of speed which a porpoise exhibits as he goes through the water. Those who spend their time crossing the ocean are familiar with the sight of these creatures saucily playing about the bows of a fast liner as she goes tearing through the water. It has been calculated that it would require no less than 15 horse-power to obtain the twenty miles an hour at which these animals can travel for long periods at a time. The explanation is that in their skins there is a wonderful system of glands, which exude oil and so minimise the influence of skin-friction. Remembering this, mechanical attempts have even been made quite recently to obtain a steel plate which would allow the oil to exude under pressure from the inside of the vessel's bows.

Possibly, nowadays, every engineer has his own formula for determining the amount of horse-power essential for a

given speed. All sorts of sliding scales and devices have been invented for this purpose, and the ideal shape of the modern propeller has still to be ascertained. It is a well-known fact that when a vessel moves through the sea she sets the water itself in motion, so that some of it actually travels with the ship; but Naval Constructor D. W. Taylor, of the United States Navy, found by experiment in 1908 that when a ship progresses the flow of the water is down forward, and then it passes under the ship, coming up again aft. Practically we can sum up the resistance which a ship has to encounter under three heads. First of all, there is the skin resistance already mentioned, which, of course, varies with the amount of wetted surface. Then after the ship has passed through the water there ensues an impeding eddy at the stern, as the reader must often have observed. Finally, there is the resistance caused by wave-making, which for vessels propelled at high speeds is an important consideration, but varies according to the design of the ship and her pace.

We have digressed somewhat from our immediate historical continuity, because not merely is it essential to appreciate some of the difficulties which the ship-man of to-day has to encounter, but in order to show that, though Fulton was very far from comprehending all the details of the relations between resistance and hull which recent experiments alone are determining, yet he was working on right lines, and with a certainty of aim that was positively unique for the beginning of the nineteenth century. Reverting, then, to the illustration on page 64, he explains in his footnote that a nice calculation must be made on the velocities of the wheels which drive the paddle-wheels, whilst the same regard must also be had for the rate at which the paddle-wheels and the boat herself are

to move. Thus, he says, supposing a boat is calculated to run at the rate of four miles an hour, the paddles and bow presenting equal surfaces in the water, then the circumference of the wheel must run eight miles an hour, of which four strike water back equal to the water divided by the boat, the other four miles, so to speak, *overtaking* the boat. But, he adds, if the paddles were made twice as large the engine would stand still. In the illustration, much of which has necessarily suffered through having to be reduced, we see an arrangement of pulleys and lines, and a weight. To the left of the diagram, *A* represents the boat which is to be propelled through the water, while *B*, shown at the extreme right of the illustration, is the paddle which is to send the ship along. Both present a flat front of four feet to the water. By the known resistance, Fulton argued, each would require twelve pounds to draw each one mile per hour, so that if the pulley and weight marked *C* weighed 24 pounds, and descended to where it is marked "No. 1," then the boat *A* would be drawn to the point marked 2 (seen just to the right of it) and the paddle would be drawn to that spot marked 8, each moving through equal spaces in equal times, twelve of the 24 pounds being consumed by the boat and twelve by the paddles. Thus half of the power is actually consumed by the paddles. Next, he says, suppose that the flat front of the paddle is reduced to one foot while the boat still remains four. "The paddle being one-fourth the size of the boat must move 2 miles an hour to create a resistance for the boat to move one mile in the same time." Finally, as we said, he concludes that the paddles acting in the water should, if possible, present more surface than the bow of the boat, and power will thus be saved.

Practically no part of the *Clermont* was an invention of Fulton: it was the manner of employing these parts scientifically that brought him his success. He was able, too, to distribute his weights so well that not only was the wooden hull able to sustain them, but the vessel floated on an even keel and was not inflicted with a list either one side or the other. To have done this in those early days of steamship building was rather more important an achievement than the average reader may imagine, but any naval architect and shipbuilder will readily grant it. The *Clermont's* boiler was set in masonry, while her condenser stood in a large cold-water cistern. Fulton threw the whole of his enthusiasm into his work, and when, in the early part of the year 1807, he was invited by the President of the United States to examine the ground and report on the possibility of making a canal to join the Mississippi and Lake Pontchartrain, the inventor, writing on the 20th of March, had to decline the invitation for, says he, "I have now Ship Builders, Blacksmiths and Carpenters occupied at New York in building and executing the machinery of my Steam Boat."

In May, 1909, four folios containing Fulton's original drawings for his first *Clermont*—she was afterwards much altered—were discovered, and a well-known American naval architect was able to draw out the plans from which the replica of the *Clermont* was built for the Hudson-Fulton commemoration, which took place from September 25 to October 8, 1909. On August 9, 1807, exactly four years to the day since that memorable sight was witnessed on the Seine, the *Clermont* was first tried, and Fulton found that his ship was able to "beat all the sloops that were endeavouring to stem tide with the slight breeze which they had." Eight days later

she began her memorable voyage on the Hudson, one of the most historic incidents in the history of the steamship. At first the *Clermont* went ahead for a short distance and then stopped, but as soon as Fulton had been below and examined the machinery, and put right some slight maladjustment, she went ahead slowly. The illustration facing page 46 is from a contemporary drawing in the South Kensington Museum, and should be compared with that here facing, which is from a photograph taken in the autumn of 1909 of the reconstructed *Clermont*, built for the Hudson-Fulton celebrations. If we have the last-mentioned picture in our minds we can easily imagine that memorable day when, with about forty guests on board, she set forth. The realistic photograph here given shows about fifty or sixty people aboard, so that we can gain some idea as to what amount of deck space was available with so many persons crowding on her. But few believed that she would succeed in achieving what she did. The crews of passing vessels, as she went gaily up this gloriously fascinating river between its hilly banks, could not understand the monster belching forth sparks from its pine-wood fuel, advancing steadily without sails in spite of wind or tide. Some abandoned their ships and fled to the woods in terror, others knelt down and said their prayers that they might be delivered from so unholy a creature. As we look down on her decks we can see her under the charge of a paid skipper, with Fulton, handsome, but anxious both as to his success and the lives of his guests, on board. Some prophesied that she would blow up, and none thought she would ever reach her destination. Those who are familiar with the characteristics of the crews of the modern steamship will learn with a smile that, of course, her chief engineer was a Scotsman, the first of that long line of

THE RECONSTRUCTED "CLERMONT" AT THE HUDSON-FULTON CELEBRATIONS, 1909.

Photographs Topical

PADDLE-WHEEL OF THE RECONSTRUCTED "CLERMONT."

serious-faced men whom Kipling and others have commemorated in "McAndrew's Hymn" and the like. Leaving New York on Monday at one o'clock, the ship arrived at Clermont, Livingston's seat, exactly twenty-four hours later, having travelled 110 miles, which is about the distance that an ordinary sailing coaster nowadays covers in the same time on the sea. Among those on board was an Englishman, the then Dean of Ripon, though the sentimental may find perhaps a fitting sequel to the first stage of the voyage, when, before the ship had yet anchored off Clermont, an announcement was made that Fulton had become betrothed to another passenger, Miss Harriet Livingston, niece of that other Livingston with whom Fulton had been so closely associated in his first steamboat efforts. It was, in fact, this same statesman who, in making the announcement, also prophesied that before the close of the nineteenth century vessels having no other motive power than steam might be able even to make the voyage to Europe. The ensuing chapters of this book will show how speedily and with what quickly succeeding changes this possibility was to be realised.

We need not weary the reader with the details of this first voyage. It is sufficient to state that the *Clermont* proceeded to Albany, covering the remaining forty miles in eight hours, having made the whole trip of 150 miles in thirty-two hours, at an average of nearly five miles an hour. The return journey to New York was made in two hours less. If we look at these two pictures of the *Clermont*, old and modern, we shall see that she was an odd, clumsy craft. Her machinery creaked and groaned as if protesting against the new service to which it was being subjected. She was fitted with a yard and square-sail on the fore-, and a spanker on her main-mast, but

during the journey to Albany and back the wind was contrary. "I had a light breeze against me," wrote Fulton, "the whole way, both going and coming, and the voyage has been performed wholly by the power of steam. I overtook many sloops and schooners, beating to the windward, and parted with them as if they had been at anchor. The power of propelling boats by steam is now fully proved." The sails, however, were retained for use on future occasions when a favourable wind might accelerate the *Clermont's* speed.

If the reader will look at the illustration facing page 70, he will be able to obtain an excellent idea of the vessel's paddle-wheels. Here is shown the port side of the replica of the *Clermont*. It will be noticed that the fly-wheels were hung outside the ship and just in front of the "water-wheels." These "water-wheels" were always getting smashed, and on one occasion, when both of them had been carried away, the engineer made use of the fly-wheels by attaching small paddle-boards to the rims, and so the voyage was completed without much loss of time. Local skippers treated the *Clermont* in pretty much the same spirit as Papin's poor ship had been welcomed by the local watermen, and the Hudson sailing-masters took a malicious delight in running foul of her whenever they thought they had the law on their side. It is not, therefore, surprising to find that Fulton, in writing to Captain Brink, whom he put in charge of her, commands him "run no risques of any kind when you meet or overtake vessels beating or crossing your way, always run under their stern if there be the least doubt that you cannot clear their head by 50 yards or more." But it was no exceptional occurrence for the *Clermont* to come limping home with only one of her paddle-wheels working. The circumference of

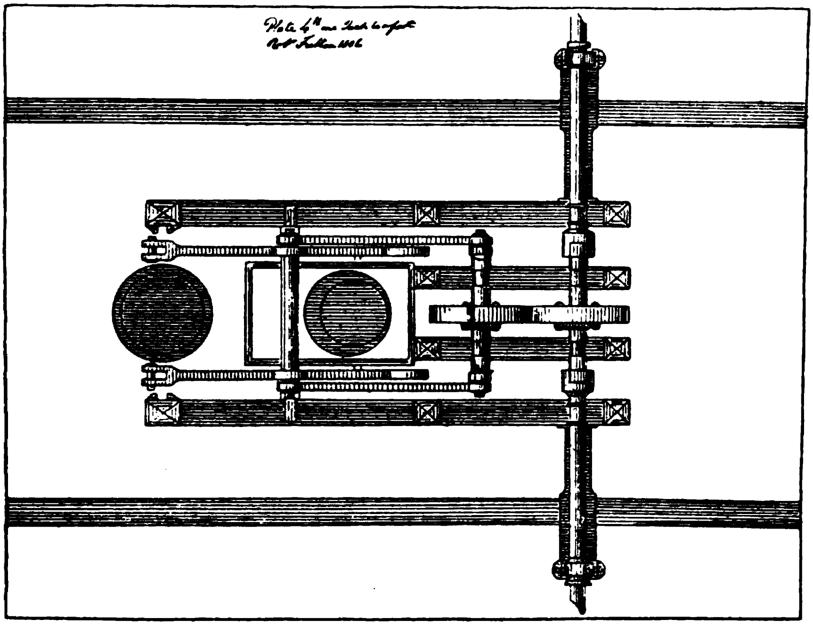
these was in each case an iron rim of about four inches, and a contemporary says they ran just clear of the water, as will be seen from the illustration, the wheels being supported, it will be noticed, by the shaft coming out through the hull. The boat was decked forward, and the stern was roughly fitted up for the accommodation of passengers, the entrance to which was from aft, just in front of the steersman, who worked a tiller. This was afterwards supplanted by a wheel, placed near the main-mast, which connected with the rudder by means of ropes. Steam hissed from every valve and crevice; there was no steam-whistle, but warning of the boat's arrival at a wharf was given by sounding a horn. After her first voyage, when it was decided to put her into commission as a regular passenger craft, she was somewhat modified. Thus, her "boiler works," which had been open, were decked over, each cabin was fitted with twelve berths, and many parts of the ship were strengthened with iron work. There was clearly a future for the steamboat commercially, not merely "because of the certainty and agreeable movements" of Fulton's ship, but whereas the average passage of the sailing packet to Albany took forty-eight hours, the *Clermont* had done the distance in eighteen hours less. She ran so successfully that at the end of her first season she cleared 5 per cent. on the capital which had been expended on her.

It will be seen from the illustrations of the boat that the *Clermont* had no bowsprit, and, also, that in one her paddle-boxes are shown, whereas in the other two they do not appear. The explanation is that originally the wheels were uncovered, but as it was found that the wheels were likely to become entangled with ropes, and also to annoy passengers by splashing water on deck, they were covered in. It will also be noticed

from the older illustration that Fulton had guards put round the paddles as a protection against the inimical sailing ships, and also to prevent damage when coming alongside a wharf. Steps from the stern end of these guards were added for convenience in discharging and embarking passengers from rowing boats. There is also existent a record by Fulton in which he even mentions that he had so placed the masts that the awning seen in the earlier illustration could be spread for the comfort of the passengers. He also claims that he was "the first who has so arranged the rudder of his Steamboat as that the pilot may stand near the centre of the boat and near the engineer to give him orders when to stop or put the engine in motion."

With regard to the engines of the *Clermont*, Fulton claimed to have been the first to use triangular beams in the body of his boat "to communicate the power from the piston rod to the Water wheels," and work his air-pump. But if the reader will turn back to the illustration on page 51, he will find that the triangular beam was also employed in the engines of his first steamboat on the Seine. During the winter of 1807-8 the *Clermont* was altered very considerably, so that her name was changed to that of the *North River*. Writing to Livingston on November 20th, Fulton suggests that a new hull be built so as to become nearly twice as stiff as she was originally, that she should carry much more sail, have a new boiler installed, additional knees and timbers, new cabins and other improvements. Under her new name this re-built craft ran regularly to Albany and back at a single fare of seven dollars a head. On her forestay she carried a fore-sail, and besides her other courses on her fore-mast she even had stun's'ls at times, a mizen with a gaff main-sail being stepped as before.

There was a ladies' cabin containing six upper and four lower berths. The engine was one of Boulton and Watt's, having a cylinder whose piston was 2 feet in diameter. On the top of the piston was a cross-head made of iron which was slid up and down between guides on the "gallows-frames," that



FULTON'S PRELIMINARY STUDY FOR THE ENGINE OF THE *CLERMONT*

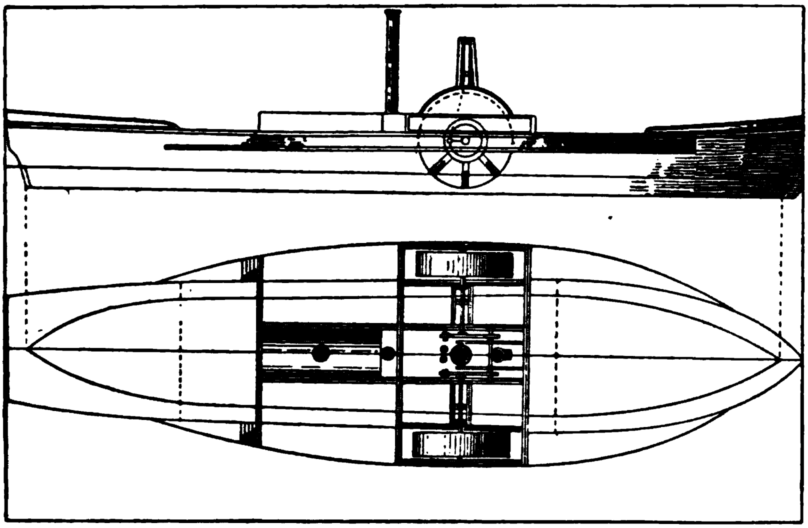
From the Original in the possession of the New Jersey Historical Society.

reached from the bottom of the vessel to 12 feet above the deck. This will be clearly seen in the second illustration of the reconstructed *Clermont* facing page 70. The "gallows-frames" are just to the left of the funnel, and the cross-head can be discerned sliding up and down the iron guides. By comparing this with the above diagram, a very fair idea will be obtainable of the working of this portion of her mechanism.

The optimists had prophesied correctly: the steamboat had come to stay. So soon as Fulton had shown the way, and during the eight years which ensued between the completion of the *Clermont* in 1807 and Fulton's death in 1815, no fewer than seventeen craft of various kinds were built by him, including the first steam frigate, and the first steam ferry-boats. Among the number of this fleet were the *The Car of Neptune,* launched in 1808, the *Paragon* in 1811, the *Fire Fly* of 1812, and the *Richmond* of 1814. Fulton had, from the first, as we saw when he wrote to Napoleon's Commissioners, the idea of opening up the Mississippi and other North American rivers by means of steamships, and no sooner had he got the *Clermont* to work satisfactorily than he wrote: "Whatever may be the fate of steamboats for the Hudson, everything is completely proved for the Mississippi, and the object is immense." When one considers that it was Fulton who introduced practical steam navigation, not only to the Hudson but to the other great rivers of North America, and that the *Clermont* was the historic embodiment of his thoughts, it seems a pity that no one has been able to trace the whereabouts of this epoch-making craft. She has vanished; and was either broken up or disguised beyond recognition.

We mentioned at an earlier stage the names of John and R. L. Stevens, who had interested themselves in steamboat experiments. Just about the time that the *Clermont* was ready for her life's work these two men had built another steamship, called the *Phœnix.* Originally intended for the Hudson River, since now the *Clermont's* success had obtained for Livingston and Fulton the monopoly of the steam navigation thereon, the two Stevenses decided to send their craft to the Delaware River. They therefore took her round to

Philadelphia by sea in June, 1809, one of the owners being in command. She arrived quite safely, and for several years plied profitably on the Delaware. This is important as being the first occasion in history when the steamship took to the sea, for it was not until the *James Watt* achieved her distinction in 1811 that a British ship had shown her full confidence



FULTON'S PLANS OF A LATER STEAMBOAT THAN THE *CLERMONT-NORTH RIVER*, SHOWING APPLICATION OF THE SQUARE SIDE-CONNECTING-ROD ENGINE.
From the Original in the possession of the New Jersey Historical Society.

in steam. Impelled by the impetus which had been given by Fulton and Stevens, the North American continent, with its vast extent of waterways, quickly realised the possibilities of the steamboat, so that in the next decade this novel type of craft became familiar in many parts.

No apology is needed to the reader for having taken up so much of his attention in witnessing the growth of the steam-

ship both on the Seine and the Hudson, for the importance of these rivers in the history of our subject is anything but insignificant. But let us turn now to see what was being done in Great Britain, where a kind of slump, or rather inertia, had been prevalent in regard to the steamship ever since the *Charlotte Dundas* had been laid aside. We must cast our eyes in the direction of the Clyde, where Henry Bell had interested himself in the steamboat problem. Like others before him, he had begun his experiments at first with hand-driven paddle-wheels, but it was not long before the inevitable conclusion was thrust on him that the power ought to be derived not from human force, but from steam. It was he who had talked the matter over with Fulton, and had actually accompanied the latter when a visit was paid to Symington and the two men witnessed a trial trip of the *Charlotte Dundas*. Bell was a simple, uneducated man, the proprietor of an hotel at Helensburgh, on the Clyde, where he also conducted a bathing establishment, and at one time possessed an engine which was in use at his hotel for pumping up sea-water for the baths. His enterprising mind argued that it would be for the advantage of his hotel if he could inaugurate a steamboat service between Helensburgh and Glasgow, and so he had the *Comet* built in 1811, by Messrs. John Wood and Co., of Glasgow. Some interesting details have been collected of this early British boat by Captain James Williamson in his book on "The Clyde Passenger Steamer: its Rise and Progress during the Nineteenth Century" (Glasgow, 1904), and in Mr. James Napier's "Life of Robert Napier" (Edinburgh, 1904). The illustration opposite this page, which represents a model of the *Comet* now in the South Kensington Museum, will afford a good idea as to her appearance. As will be seen,

THE "COMET."

From the Model in the Victoria and Albert Museum

ENGINE OF THE "COMET"

In the Victoria and Albert Museum.

she was a paddle-boat, and originally had two wheels on either side, but one pair was removed later, as the arrangement was found to be of too complicated a nature to work satisfactorily. She was far less of a ship than the *Clermont*, and much more of a river boat. She did not carry even a single mast, but, as will be noticed in the model, she utilised her thin, lofty smoke stack for this purpose and set a yard across it, as the *Clermont* had done on her fore-mast. On this yard she set the usual square-sail, while from the end of the stumpy bowsprit she also set a triangular jib. This model may be taken as authentic in its details, and it was to David Napier that Henry Bell entrusted the task of making the boiler and castings. The boat was of about twenty-five tons burthen, 42 feet long, 11 feet wide, and 5 feet 6 inches deep; was driven by a condensing steam engine developing four horse-power, and her greatest speed through the water was five miles an hour. Her cylinder was vertical, the piston-rod driving a pair of side levers. The crank shaft, on which was fixed a large, heavy fly-wheel, was worked from the levers by a connecting rod. A reference to the illustration—which is from a photograph of the identical engine used in this vessel, and presented to the museum by Messrs. R. and J. Napier—will reveal these details. Whereas the *Clermont* had employed the triangular beam or bell-crank for conveying the power from the piston-rod to the paddle-wheels, as we saw just now, the *Comet* had what was known as the "grasshopper" or half-beam type. The steam was generated from a boiler set in brickwork, and placed on one side of the engine. When originally she had her four paddle-wheels—two on either side—these were driven by means of an intermediate wheel, which engaged them both by means of spur gearing. The

paddles were then, as will be noticed in the illustration, simply placed on detached arms, but when the alteration was made complete wheels were given to her. She was fitted with a fo'c'sle and after-cabin, of which the hatches will easily be recognised in the model. The engine-room took up the intervening space amidships.

Writing now in the year when everyone has been interested in the coming of Halley's Comet, it is interesting to observe that Henry Bell's ship was so called from the fact that a meteor had appeared in the heavens about that time. In August, 1812, she was advertised as being ready to ply up and down the Clyde "to sail by the power of air, wind, and steam," the announcement also stating that "the elegance, safety, comfort, and speed of this vessel require only to be seen to meet the approbation of the public, and the proprietor is determined to do everything in his power to merit general support." Apparently, however, the "general support" was not forthcoming, for commercially the *Comet* proved a failure. Historically she was a success, for her influence was undoubtedly for good, and Napier made some interesting observations, from which he was able to deduce important conclusions. Those who are familiar with the history of the sailing ship will be aware that at the beginning of the nineteenth century both the large ocean-going ships and the small coasters were distinguished by their remarkably heavy and clumsy proportions. Especially was the bow still made bluff and full, since the idea in the minds of the ship-designers was that their vessels should rather *breast* the waves than, cut clean through them, as the clipper-ships afterwards taught should be the manner. It was the still surviving Dutch influence of the sixteenth and seventeenth centuries which had caused this fashion in

naval architecture to prevail for so long. In a sailing boat, where it was desired to carry sail well forward near the bows—as was essentially a Dutch custom—and where it was desired to keep the ship as dry as possible, there was some reason for the high, blunt bow. But with the advent of steam these conditions disappeared. It is obvious to every landsman that whatever seaworthy qualities the forward end of a boat thus designed may possess, the smashing blows which her obstinate form exchanges with the waves must be a great hindrance to progress over the water in comparison with the clean, knife-like movement of the more scientifically designed craft. And so, long before ever the clipper-ships appeared, the same idea struck David Napier. He spent some time in making passages from Scotland to Ireland in the Belfast sailing packets of that time, and came to the conclusion that the full bow was not suitable for easy propulsion. He followed up these observations by making further experiments with a model in a tank, and continually modified the former until he was satisfied. As long as ever she showed an increase of speed he kept on fining away her bow and thus diminishing her resistance to the water. What he had in mind, after seeing the achievements of the *Comet*, was the inauguration of a steam cross-channel service between Scotland and Ireland to compete with the sailing packets. At length, having brought his model to what he deemed was a state of perfection, he had a full-sized ship built after her by William Denny, the founder of the well-known shipbuilding firm. The result was the *Rob Roy*, a vessel of about ninety tons and thirty nominal horse-power. In 1818 she began running between Greenock and Belfast, after which she was bought by the French Government and kept up communication between Calais and Dover, though the

first time the English Channel was crossed, from Brighton to Havre, by a steamship was in the year 1816 by the *Majestic*. Thus, the *Comet*, if not remunerative to her owner, was anything but a creation of no account.

Bell's ship did not belie her name, for her life was literally meteoric. She had been taken "outside," and on December 13th, 1820, whilst near Crinan, on the West Coast of Scotland, was unable to wrestle with the strong easterly wind and nasty tide-race and was wrecked, Bell himself being on board; happily no lives were lost. In the following year, *Comet* the second was built, but she also foundered in 1825, through collision. In the first days of the *Comet*, when engineers were working with insufficient data, it was generally believed that it would be impossible to make a steamship's machinery of sufficient strength to withstand the shock of crashing into a heavy sea, and for some time no steamer went far outside. There is an interesting anecdote that James Watt, who, though largely responsible for the successful inauguration of the steamship in the hands of Fulton, was none the less never directly connected with the new industry, in his old age visited his native town of Greenock. This was in the year 1816, or four years after the *Comet* had commenced running. On this occasion he took a trip in one of these steam vessels to Rothesay and back, during which he entered into conversation with the engineer and pointed out to him the method of "backing" the engine, and endeavoured with a foot-rule to demonstrate his point. The engineer, however, was unable to grasp the inventor's meaning, but eventually, throwing off his coat and putting his hand to the engine, Watt explained the idea of using a back-stroke; for, previously to this the back-stroke of the steamboat engine was not adopted, and the practice

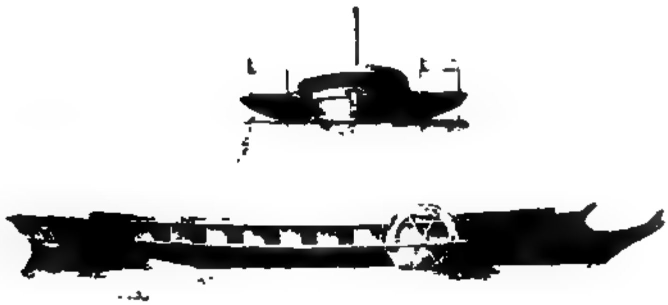
was to stop the engines some considerable time before coming up to moorings in order to allow of the diminution of the speed. The incident is related in Williamson's "Memorials of James Watt," and quoted in Chambers's "The Book of Days."

Not merely, then, in North America, but in Northern Europe the steamship had become a practical and interesting success. On the Clyde the impetus given by the *Comet* had caused the development of the steamboat to be more rapid. Vessels larger than Bell's boat were being built and put into actual service, and in 1815 one of them was sent round to the Mersey and thus began the important river steamboat service which is now so significant a feature of the port of Liverpool. The River Thames, in like manner, was to yield to the coming of the steamboat. Although the London newspapers of 1801 refer to the fact that on July 1 of that year an experiment took place on the Thames for the purpose of working a barge or any other heavy craft against the tide "by means of a steam-engine of a very simple construction," and go on to state that "the moment the engine was set to work, the barge was brought about, answering her helm quickly," and that she made way against a strong current, at the rate of two miles and a half an hour, yet this was one more of those isolated incidents which came and went without leaving in their wake any practical result. At a later date a steamer which had been running between Bath and Bristol was brought to the London river by means of canal, and history repeated itself once more. Just as Papin and Fulton had suffered by the unwelcome attentions of the local watermen, so it was in this case. The men who earned their living on the waters of the Thames showed so strenuous an opposition that the boat had to be taken away.

However, in 1815, a steamboat called the *Marjory*, one of the products of the Clyde, came round to the Thames and commenced running daily between Wapping Stairs, near the present Tower Bridge, and Gravesend; and another boat, the *Argyle*, came from the Clyde also. Both vessels were, of course, of wood, and both were propelled by paddle-wheels. The latter was afterwards re-named the *Thames*, and was the inaugurator of those voyages now so dear to the Cockney between London and Margate. After an exciting voyage from the Clyde, she steamed up the Thames from Margate to Limehouse, a distance of seventy miles, at an average of ten miles an hour. Both of these vessels were of about seventy tons burthen.

We mentioned just now that James Watt always refrained from interesting himself financially in the steamboat, although it was his own improved form of engines which made the steamboat a success. But "like father" is not always "like son" in the race of progress; and in 1816 we find James Watt, Jun., purchasing a steamboat called the *Caledonia*, which had also come round from the Clyde to the Thames. After fitting her with new engines he took her from Margate to Rotterdam and so on to Coblenz: she was eventually sold to the King of Denmark. Other vessels of about eighty or ninety feet in length, sometimes with engines by Boulton and Watt of about twenty horse-power (nominal), were also presently witnessed on the pea-green waters of the Thames estuary. And before the second decade of the nineteenth century was ended steamer communication for cross-Channel services between England and France, and England and Ireland had already been instituted. But as I shall deal with this branch of steamship enterprise in a separate chapter, I need not make any further remark upon that subject now.

SS. "ELIZABETH" (1815).



RUSSIAN PASSENGER STEAMER (1817).

From Drawings in the Victoria and Albert Museum

In the history of the sailing ship the flow of progress was from east to west, from Babylon to North America, and then it ebbed back again, bearing in its stream improvements which newer nations had been able to effect to the sail-propelled ship. To an extent, something of the same kind happened in the case of the steamship. The latter's physically-driven, paddle-wheel prototype began, if not in China, at least in the Mediterranean, and the first efforts of steam propulsion were made not many hundred miles north of this. Then, after the Fulda, the Saône, and the Seine, the movement was to the Hudson, and so back to Europe through Great Britain and on to Germany and Russia. Of the progress in steam navigation made in the two latter countries about this time the illustrations facing page 84 are interesting instances, and we shall deal with them presently. But before we proceed to discuss them let us turn back for a moment to Robert Fulton. After he had at length established the steamboat as a thoroughly sound concern in America we find him not unnaturally sighing for other countries to conquer. Accordingly he set his mind on introducing the steamboat not merely on the chief rivers of North America, but even on the Ganges and the Neva. The year in which Bell's *Comet* had come into service Fulton had actually entered into a contract with one Thomas Lane to introduce steamboats into India, and on April 12th of that year he wrote to a Russian gentleman, who was then staying in London, with reference to obtaining an exclusive contract for twenty years, for establishing a steamboat service between St. Petersburg and Cronstadt within three years after obtaining the grant. It is evident from Fulton's correspondence that Imperial permission for this was obtained. Fulton, however, died in the year 1815, and at the time of his death the steam-

boat *The Emperor of Russia* was in course of construction previous to being transferred to Russian waters. This enterprise was postponed and subsequently taken up by other contractors. But the same year (1815) we find Charles Baird engaged in doing what Fulton would have carried out had he lived. The upper illustration, then, which faces page 84 represents a drawing of the steamboat *Elizabeth*. Originally a barge, she was rebuilt and engined by Baird in 1815 at St. Petersburg for service on the Neva. The steering arrangement is not dissimilar to that of some of the Thames sailing barges of to-day, with the use of the tackle leading from the rudder through the ship's quarter to the helm. The reader will doubtless be not a little amused to notice the brick chimney which stands up in the boat as if rising from a factory. The engine is hidden away underneath the deck, but it was of the side-lever type, of which we have already spoken, with a single cylinder and air-pump. The boiler will be seen placed aft. The weight of the paddle-wheels was partly supported by the rectangular frame-work which will be seen stretched across the hull. The paddle-wheels had each four floats, which were kept level by means of bevel gear. The other illustration facing page 84 shows another steamer, which Baird built two years later for passenger traffic between St. Petersburg and Cronstadt. It will be noticed that, as in all these early steamboats, the paddle-wheels were placed far forward towards the bows. In this ship both paddle-wheels were fitted with six floats, which were driven at fifty revolutions per minute by means of a side-lever engine that had a large fly-wheel. The arrangement of this ship's engines was similar rather to those of the *Comet* than of the *Clermont*. Looking at the lower drawing in this illustration we can easily see how she was propelled. Amidships is the boiler, from

which steam is conveyed to the cylinder, through which appears the piston-rod, which in turn connects with the side-lever, that is placed as low as it can be in the boat. The connecting rod comes up from the forward end of the side-lever to the crank, which is attached to the shaft, and the latter, revolving, of course turns the paddle-wheels.

And here it may not be out of place to say something concerning the survival of the beam engine. I have already referred on an earlier page to its introduction and traced its development from Newcomen's atmospheric engine. When, in the early days of the steam engine, its use had been limited to pumping out water from mines, one connecting rod was employed in pumping and the other was driven up by the steam in the cylinder. Then, when the engine was made, not for pumping, but for giving rotatory motion, the connecting rod which had been in use for pumping was used to give a rotatory motion, by means of either the sun-and-planet movement (as in Watt's patent) or by means of a crank (as in the patent which his workman stole from him). In America Watt's beam engines were imitated very closely, and to-day, as every visitor to New York is aware, the curious sight is seen of enormous ferry-boats, towering high above the water, with the beam and connecting rods showing up through the top of the ship. Now this idea is all very well where the steamer is concerned only with navigation on rivers and peaceful waters, but for ocean steaming, where the deck needs to be covered in from the attacks of the mighty seas, it is out of the question. Therefore, since it was advisable to retain the beam in some form, and it could not be allowed to protrude through the deck, the obvious expedient was adopted of placing it below, but as far down in the ship as possible. As a general

statement we shall not get far wrong if we state that thus placed, at the bottom, with the rods working upwards instead of downwards, it was really a case of turning the engine upside down. Thus arranged it became known as the side-lever engine, and now, if the reader will look again at the bottom illustration facing page 84, he will see our meaning. By turning the illustration round, so that the beam or side-lever is at the top, this resemblance to the old-fashioned beam engine becomes still more apparent. Later on we shall be able to show a more complicated form of the side-lever engine, but for the present this may suffice for the interest of the non-technical reader. For many years the side-lever was the recognised form of marine engine, and its advantages included that of being remarkably steady in its working because its parts were so nicely balanced. Moreover, it was easy to drive from the beam the various auxiliary parts, such as the air-pump. It was also very strong, though both heavy and costly, as it became in the course of time more complicated.

Although it is true that in Fulton's *Clermont* the beam was placed below the piston-rod, yet that was entirely owing to English influence, as represented in Boulton and Watt, who had manufactured this engine, or at any rate a good many of its parts. It is now that the dividing line comes between the two types, English and American. "From this primitive form," says Admiral Preble, in his volume already quoted, "the two nations diverged in opposite directions—the Americans navigating rivers, with speed the principal object, kept the cylinder upon deck and lengthened the stroke of the piston: the English, on the other hand, having the deep navigation of stormy seas as their more important object, shortened the cylinder in order that the piston-rod might work entirely

under deck, while Fulton's working (walking) beam was retained." From the engine, in fact, which Boulton and Watt had constructed at Soho for Fulton, by far the majority of the engines for the earliest steamboats took their pattern. And if to the Americans belongs the credit of having so thoroughly and so quickly developed the steamboat navigation of large rivers, it is the British, as we shall see shortly, who have been the pioneers of ocean navigation in steamships.

The upper illustration facing page 90, which has been taken from a contemporary engraving, is worthy of notice as being the first steamer actually built in Germany. She represents rather a retrogression than an advance in the story of the steamship, for she was following still on those lines which had been in mind when Miller's double-hulled ship and the *Charlotte Dundas* were launched. This vessel, the *Prinzessin Charlotte*, was built by John Rubie at Pichelsdorf in 1816, for service on the Elbe, Havel and Spree. As will be seen from the illustration, her paddle-wheel was placed amidships and covered in. She was driven by an engine possessing 14 horse-power and made by J. B. Humphreys. Her long, lanky smoke-stack is supported by numerous stays, while her double-rudders, though still preserving the helms as used in contemporary sailing ships, are moved by means of a steering wheel. Clumsy and beamy, she is inferior in design to the *Comet*, and would no doubt have needed all the help of her twin-rudders to get her round some of the narrow reaches of the river. In the adoption and employment of the steering wheel neither the *Prinzessin Charlotte* nor the *Clermont* was the pioneer of this more modern method, its evolution having come about on this wise: as the tillers became heavier when the size of ships increased and the pull on them became greater, some

sort of lanyard was first attached to them so as to get a purchase and divide the strain; otherwise the steersman would not have been able to control the ship. We see this as far back as the times of the Egyptian sailing ships. In medieval times and even in the seventeenth century the big, full-rigged ships were still steered by a helm in the stern, the pilot shouting down his orders to the steersmen placed under the poop. Then, in order to counteract the wild capers which some of these vessels had a tendency to perform in a breeze, it was an obvious expedient to fit up an arrangement of blocks and tackles to the tiller. From this came the transition to the employment of these in connection with a winch, such as had been used for hoisting up the anchor. This winch was driven by means of "hand-spikes," a method that was not conducive to rapid alteration of the ship's course. But in the eighteenth century, when ships were better designed, and many improvements were being introduced, the handspikes were discarded and the spoked wheel was connected with the barrel of the winch, placed not 'thwart-ship, but fore-and-aft, so that not merely could the direction of the ship's head be altered more quickly, but a steadier helm could be kept, because it was less difficult to meet the swervings of the vessel from her proper course. As everyone knows, this steering-wheel has been improved by many minor alterations, and ropes have given way to chains and steel wire: but though steam-steering gear is now so prominent a feature of the modern steamship, the wheel itself is not yet superseded.

Already, then, the steamboat had shown herself capable of doing her work on inland waters, and even for short voyages across Channel, as well as for coasting within sight of land. Independent of calms, currents and tides, she was a being of a

THE "PRINZESSIN CHARLOTTE" (1816).

From a Contemporary Print.

THE "SAVANNAH" (1819).

different kind as compared with the sailing ship and was carving out for herself an entirely novel career of usefulness. But the pessimists believed that here her sphere ended; the long ocean voyages could never be undertaken except in the sail-carrying ships. However, in the year 1819, the first attempt was made to conquer the North Atlantic by means of a ship fitted with a steam engine. In the lower illustration facing page 90 will be seen the *Savannah*, a full-rigged ship of 350 tons burthen which was built in New York in 1818 as a sailing vessel pure and simple. That, it will be remembered, was eleven years after the launching of the *Clermont*, and during these eventful years there had been plenty of opportunity for those who wished to obtain proof of what steam could do for a ship. Whilst the *Savannah* was still on the stocks, one Moses Rogers, who had followed the efforts of both Stevens and Fulton, and had even commanded some of the early steamboats, suggested to Messrs. Scarborough and Isaacs, of Savannah, that they should purchase this ship; which eventually they did. Therefore, after being fitted with her engine, a steam trial trip was made in March, 1819, round New York Harbour, and a few days later she left for Savannah under sail. During this voyage of 207 hours she was practically nothing but a sailing ship, for her engine was only running for four and a half hours. On the 22nd of May she set forth from Charleston and steamed outside. It will be noticed on referring to the illustration that there were no paddle-boxes to cover her wheels, and a remarkable feature of the *Savannah* was her ability suddenly to transform her character as a steamship to a sailing vessel, and vice versa. Within twenty minutes she could take off her paddle-wheels, and away she could go without any hindrance to her speed.

So it was, then, after she had brought up outside Charleston. Unshipping her wheels she got under weigh early in the morning of May 24th, and arrived off the coast of Ireland at noon of June 17th, and three days later was off the bar at Liverpool. But this voyage proved little or nothing of the capabilities of the ocean steamship; for of the twenty-one days during which she was at sea the *Savannah* only used steam for eighty hours, and by the time she had arrived off Cork she had used up all her fuel. However, having now taken on board what she needed, she was able to steam up the Mersey with the aid of her engines alone. From Liverpool she went to the Baltic, using her engine for about a third of the passage. Thence she returned to America, having unshipped her paddle-wheels off Cronstadt, but, after crossing the Atlantic and arriving off the Savannah river, she adjusted her wheels once more and steamed home. Shortly afterwards her engines were taken out of her, and she ended her days as a sailing packet. Although her voyages did nothing to help forward the ocean steamer, yet she caused some amazement to the revenue cruiser *Kite*, which espied her off the coast of Ireland. Seeing volumes of smoke pouring out from this "three-sticker," the *Kite's* commander took her for a ship on fire and chased her for a whole day. The illustration gives a fairly accurate idea of the ship, though the bow has not been quite correctly given, and should show the old-fashioned and much modified beak which survived as a relic of medieval times. It will be noticed that the distance which separates the main and fore-mast was sufficiently great to allow of plenty of room for the engine and boiler.

In the meantime the steamship was slowly but surely coming into prominence and recognition, and the year 1821 was far from unimportant as showing the practical results

which had been obtained. As proof of the faith which was now placed in steam, the first steamship company that was ever formed had already been inaugurated the year before, and in 1821 began running its trading steamers. This was the now well-known General Steam Navigation Company, Ltd., whose first steamer, the *City of Edinburgh*, was built on the Thames by Messrs. Wigram and Green, whose names will ever be associated with the fine clippers which in later years they were destined to turn out from their Blackwall yard. The steamship *City of Edinburgh* was launched in March, 1821, for the Edinburgh trade, and created so much attention that the future William IV. and Queen Adelaide paid her a visit, and expressed surprise at the magnificence of the passenger accommodation. The machinery (which was only of 100 horse-power) was described by the contemporary press as "extremely powerful." In June of that year was also launched the *James Watt*, of which an illustration is given from an old water-colour. This vessel was built by Messrs. Wood and Co., of Port Glasgow, and was referred to by the newspapers of that time as "the largest vessel ever seen in Great Britain propelled by steam." The *James Watt*, it will be seen, was rigged as a three-masted schooner, with the typical bow and square stern of the period. She was of 420 tons, and measured 141 feet 9 inches in length, 25½ feet wide, and 16½ feet deep. She had a paddle-wheel, 18 feet in diameter, on either side of the hull. These were driven by engines of the same horse-power as those of the *City of Edinburgh*, which had been made by Boulton and Watt. It was in this year also that the *Lightning*, a vessel of about 200 tons and 80 horse-power, gained further confidence for the newer type of vessel, for she was the first steamship ever used to carry mails.

Before the third decade of the nineteenth century was closed, a little vessel named the *Falcon*, of 176 tons, had made a voyage to India—of course, via the Cape—and the *Enterprise*, a somewhat larger craft of 470 tons, had also done the passage from England to Calcutta; but like the *Savannah's* performance, these voyages were made partly under steam and partly under sail, so that these vessels may be regarded rather as auxiliary-engined than as steamships proper. At the same time, the *Enterprise* was singularly loyal to her name, for out of the 113 days which were taken on the voyage, she steamed for 103.

Let us now pause for a moment to witness some of the changes which were going on in regard to the machinery for steamships. In the engines which were installed in the Russian ship shown opposite page 84 we saw how the beam had become the side-lever, and why it had been placed in this position in the steamboat. This had become the customary type for steamships which were still propelled by paddle-wheels, and the perfected development had been due to Boulton and Watt, dating from about 1820. Until about 1860 this type was used most generally, until ocean-going steamers discarded the paddle-wheel for the screw. It is, therefore, essential that before proceeding farther we should get well-acquainted with it, and we shall find that following the lead which had been given them, especially by the famous Robert Napier, marine engineers began to build these types, as well for deep-sea ships as for river-going craft. The illustration here facing, which has been taken from a model in the South Kensington Museum, represents the regular side-lever type, the full-sized engines having been made by a Poplar firm in 1836 for the *Ruby*, which plied between London and Gravesend,

THE "JAMES WATT" (1821).

From a Water-Colour Drawing in the Victoria and Albert Museum.

SIDE-LEVER ENGINES OF THE "RUBY" (1836).

From the Model in the Victoria and Albert Museum.

a vessel of 170 tons, and the fastest Thames steamer of that time. On referring to our illustration, the side-lever will be immediately recognised in the fore-ground at the bottom. To the left of this are the two cylinders, side by side. The side-lever is seen to be pivoted at its centre, whilst at the reader's left hand the end of this is joined by a connecting rod. Thus, as the piston-rod is moved upwards or downwards, so the left-hand half of the side-lever will move. At the opposite, right-hand, side of the latter the connecting rod will be observed to be attached to the side-lever, whilst the other end of the connecting rod drives the crank; the latter, in turn, driving the shaft on either end of which will be placed a paddle-wheel. In this engine before us there are two cranks, of which one is seen prominently at the very top of the picture. Each connecting rod is attached to two side-levers, one on either side of the cylinder, by means of a cross-head. Similarly at the piston-rod there is also a cross-head, with a connecting rod on either side, of which one only is visible. Later on a modified form of this type of engine was introduced in order to economise space, for one of the great drawbacks of the side-lever engine was that it took up an enormous amount of room, which could ill be spared from that to be devoted to the carrying of cargo or the accommodation of the passengers. In this modification the cylinders, instead of being placed side by side, or athwartships, were fore and aft, the one behind the other.

In 1881, there was built in Quebec, to run between there and Halifax, a steamer called the *Royal William* (not to be confused with a vessel of the same name to which we shall refer presently). The engines were made by Boulton and Watt, and dispatched across the Atlantic to Montreal, where

they were installed. In 1833, after taking on board over three hundred tons of coal at Pictou, Nova Scotia, she started on her journey to the South of England, and arrived off Cowes, Isle of Wight, after seventeen days, having covered a distance of 2,500 miles. There is some doubt as to whether she steamed the whole way, or whether she used her sails for part of the time. At any rate, she measured 176 feet long, 43 feet 10 inches wide (including her paddle-boxes), and after calling at Portsmouth, proceeded to Gravesend, and was afterwards sold to the Spanish Government.

We now come to the year 1838, in which a handful of steamers made history, and showed how uncalled-for had been the ridicule which the pessimists had cast at the steamship. With this year we reach the turning-point of the steamship, and from that date we may trace all those wonderful achievements which are still being added to year by year. Hitherto no vessel had crossed the Atlantic under steam power solely. Because of the large amount of fuel consumption which was a necessary failing of the early steamships, in proportion to the amount of steam developed, it was denied that it would ever be financially possible for steamers to run across oceans as the sailing packets were doing, even if they were capable of carrying sufficient fuel together with their passengers and cargo. But deeds were more eloquent than the expounding of theories, and the first surprise was quickly followed by another, far from inferior. The first of these epoch-making steamers was the *Sirius*. She was rigged as a brig, like many of the contemporary sailing ships which then carried mails, passengers, and cargo between the Old World and the New, whose unsavoury characters had earned for them the nickname of "coffin-brigs." This *Sirius* was a comparatively

THE "SIRIUS" (1838).

From a Contemporary Drawing in the Victoria and Albert Museum

THE "ROYAL WILLIAM" (1838).

By permission of the City of Dublin Steam Packet Co.

small ship of 708 tons, and quite small enough to cross the Atlantic in the weather which is to be found thereon. She measured only 178 feet along the keel, was 25½ feet wide, her hold was 18¼ feet deep, and her engines developed 320 horse-power. Built for the service between London and Cork, she was specially chartered for this transatlantic trip by the British Queen Steam Navigation Company, whose own vessel, the *British Queen* (shown opposite page 102), was not yet ready, owing to the fact that one of her contractors had gone bankrupt. With ninety-four passengers on board, the *Sirius* steamed away from London and called at Queenstown, where she coaled. After clearing from the Irish port, she encountered head winds, and it was only with difficulty that her commander, Lieut. R. Roberts, R.N., was able to quell a mutiny among the crew, who had made up their minds that to try and get across the North Atlantic in such a craft was pure folly. Having been seventeen days out, the *Sirius* arrived off New York on April 22nd, and before the end of her journey had not merely consumed all her coal, at a daily average of 24 tons, but had even to burn some of her spars, so that she had got across just by the skin of her teeth. But it was her engines which had got her there and not her sails; the former were of the side-lever type to which we have just referred.

The next day came in the *Great Western*, a much larger craft, that had come out of Bristol three days after the *Sirius* had started; and in her we see the prototype of those enormous liners which go backwards and forwards across the Atlantic to-day with a regularity that is remarkable. Unlike the little *Sirius*, the *Great Western* had been specially designed for the Atlantic by that engineering genius, Brunel, who, like his ships and his other works of wonder, was one of the most

remarkable products of the last century. She was built with the intention of becoming practically an extension of the Great Western Railway across the Atlantic, and in order to be able to withstand the terrible battering of the seas, which she would have to encounter, she was specially strengthened. Here was a vessel of 1,321 tons (gross), with a length of 236 feet over all, with about half her space taken up with her boilers and engines. Now the strain of so much dead-weight in so long a ship whose beam was only 35 feet 4 inches, or about one-seventh of her length, had to be thought out and guarded against with the greatest care. And let us not forget that at this time vessels were still built of wood, and that, except in a few instances, iron had not yet been introduced. She was given strong oak ribs, placed close together, while iron was also used to some extent in fastening them. The advantage of making an ocean-going vessel long is that she is less likely to pitch in a sea, and will not dip twice in the same hollow; and if she is proportionately narrow in comparison with her length, she will also roll less than a more beamy craft. But the difficulty, so long as wood was employed, was to get sufficient longitudinal strength to endure the strains of so long a span. We shall be able to get some idea of this when we consider the behaviour of a vessel in a sea. Waves consist, so to speak, of mountains and valleys. If the waves are short and the vessel is long, then she may stretch right over some of them; but if the contrary is the condition, then, while her 'midship portion is supported by the water, her fore and aft ends are inclined to droop, so that in a very extreme case she would break in two. At any rate, the tendency is for the centre of the ship to bend upwards and the unsupported ends to droop. This is technically called "hogging." In the reverse

circumstance, when the ends are supported on the tops of two mountains of waves, whilst the centre of the ship spans, unsupported, the intervening valley, the tendency is to "sag." Now this has to be allowed for in the construction of the ship, and, as already pointed out in my "Sailing Ships and Their Story," this was understood as far back as the times of the Egyptians, who counteracted such strains as these by means of a longitudinal cable stretched tightly from one end of the ship to the other. But with the coming of steamships there was another problem to be taken into consideration. Engines, boilers, fresh water for the boilers, coal and so on are serious weights to be placed in one part of the ship. (In the case of the *Great Western*, the first three alone weighed 480 tons, although the gross tonnage of the whole ship was only 1,321.)

Throughout the length of the ship, then, she is subjected not merely to irregular strains by the peaks and valleys of the waves, but by the distribution of weights. Her structure has to undergo the severest possible stresses, and these are different when the ship is loaded and when she is "light." If you divide a ship into sections transversely, as is actually done by the designer, you will find that some parts are less buoyant than others, no matter whether your ship is made of wood, iron, or steel. Those sections, for instance, which contain a steamer's machinery will have much inferior buoyancy, and, indeed, were you to sever them from the ship and seal them up so as to be perfectly water-tight, they would in many cases sink. Therefore, this irregularity of buoyancy has to be met by making the more-buoyant sections help to support the less-buoyant. In actual shipbuilding practice it is customary to regard the greatest stress to a ship as occurring when she is poised on the crest of a wave, and it is usual to

suppose, in order to safeguard her manner of construction, that she is poised upon the crest of a wave whose length from trough to trough is equal to the length of the ship, and the height of the wave from trough to crest to be one-twentieth of its length when 300 feet long and below, and one twenty-fifth when exceeding that length.

We have digressed a little from our immediate subject in order to put into the mind of the general reader some conception of the difficulties which Brunel had to encounter when he set to work to produce such a vessel as the *Great Western.* That she was built on sound lines is proved by the service which she rendered to her owners before she was finally broken up in 1847. On her first return voyage from New York she took fifteen days, and the *Sirius* seventeen. The *Great Western* had no such trouble with her "coal-endurance" on her maiden voyage as the *Sirius* had suffered, for she had reached New York with one quarter of her coals still unconsumed, and the obvious conclusion which came to any reasoning mind was that it certainly paid to build a vessel big enough to carry plenty of fuel. But the *Great Western* "paid" in more senses than this; and at the end of her first year, her directors were able to announce a dividend of 9 per cent. Thirty-five guineas was the fare in those days, and the largest number of passengers carried on any one of her journeys was 152.

Like her contemporaries, the *Great Western* was fitted with side-lever engines, built by Maudslay. Steam was generated from four boilers, and conducted into two cylinders, her daily consumption of coal being about 33 tons. A model of one of her paddle-wheels, which were 28 feet 9 inches in diameter, is here illustrated. This type is known as the "cycloidal" wheel, in which each float, instead of being made of one solid

THE "GREAT WESTERN" (1838).

By permission of Messrs. Henry Castle & Sons.

PADDLE-WHEEL OF THE "GREAT WESTERN."

From the Model in the Victoria and Albert Museum.

piece of material, is composed of several horizontal widths arranged after the manner of steps in a cycloidal curve, as will be seen by looking at the right-hand of the wheel. It will be noticed that through the space left between each "step" the water could penetrate when the wheel was in the sea, but when revolving out of it, the resistance to the air was diminished because the latter was allowed to get through. As the paddle came in contact with the sea, the concussion was lessened, and thus there was not so much strain on the engines. The *Great Western* employed the type introduced by Joshua Field in 1833, but this form was brought in again by Elijah Galloway two years later.

So far we have seen steamers running from London and from Bristol to New York. Now we shall see the first steam-vessel crossing from Liverpool to New York. Facing page 96 is the other *Royal William*, which was built in 1838 for the Irish passenger trade between Liverpool and Kingstown, and owned by the City of Dublin Steam Packet Company, by whose courtesy this picture is now reproduced. The *Royal William* was 3 feet shorter than the *Sirius*, but 2 feet wider, and with a hold just 6 inches shallower. In July of that same memorable year, the *Royal William* made her maiden trip from Liverpool to New York, having been built and engined at the former port. In was no doubt a great temptation to emulate what the *Sirius* had been the first to perform, especially as the two ships were so similar in many respects. Outward bound, the *Royal William* did the trip in about the same time as the *Sirius*, though her return journey occupied about a day and a half less than that of the other vessel. But these vessels were not big enough, nor seaworthy enough, for the toil of the Atlantic, and both were soon taken off from this

route. The illustration reproduced is from an engraving after a sketch made of the *Royal William*, as seen in the Atlantic on July 14th, 1838, when in latitude 47.30 N., longitude 30.0 W., on her first voyage to New York, and the landsman in looking at the waves which the artist has depicted may find some assistance in reading our previous remarks on "hogging" and "sagging" in this connection.

Finally, we come to the *British Queen*, which was yet another vessel to steam across the broad Atlantic, and to show once more that it was neither good fortune nor the powers of any single vessel that had conquered the ocean, but the building of the right kind of ship, engined with suitable machinery. Built in London, and installed with engines by Robert Napier (by the courtesy of whose kinsman, Mr. James Napier, the illustration is here given), the *British Queen* was considered a wonder in her day, and even exceeded the dimensions of the famous *Great Western*, costing as much as £60,000 to build. As will be seen, she is neither brig- nor ship-rigged, but is a barque. In spite of the hideous old stern of those times and the old-fashioned square ports, and the medieval custom of stowing one of her anchors abreast of the fore-mast—a practice which survived until well into the nineteenth century—her appearance shows that she was an advance on what had gone before. She had about seven beams to her length, and her bow gives evidence that the old Dutch influence was at last being forsaken: it is, in fact, the transition stage before the clippers modified it still more. The same long space which we noted in an earlier ship, extending between the fore- and main-mast to afford room for the engines, will here be recognised, and the paddle-wheels, unlike those of the early river craft, are placed about amidships. In designing her with

THE "BRITISH QUEEN" (1839).

By permission of James Napier, Esq.

THE "BRITANNIA," THE FIRST ATLANTIC LINER (1840).

From a Model. By permission of the Cunard Steamship Co.

about 40 feet greater length than the *Great Western* had possessed, the aim was no doubt to attain not merely sufficient space for passengers, cargo, engines and ample fuel, but also to be able to wrestle with the long Atlantic waves, whose average length has been computed at about 200 feet. Seventy years ago this *British Queen* was designed to be 275 feet over all; to-day, the *Lusitania* is 760 feet thus measured, and it is this appreciation of the value of length which has a good deal to do with the evolution of the modern liner from being a moderate-sized vessel to one of enormous proportions. In her first voyage from Portsmouth to New York, the *British Queen* kept up an average speed for one day of over ten knots, whereas the *Great Western* had on her maiden voyage outward-bound averaged about two knots less. Leaving Portsmouth on April 2nd, 1839, the *British Queen* arrived in New York on April 16th, or three days quicker than the first *Royal William* had done the journey in the opposite direction under sail and steam. The *British Queen* consumed about 618 tons of coal on the way.

Thus we have seen the steamship arrive at a stage very far from being merely experimental. We have watched her gradually grow from her infancy, when she was good only as a tug or river craft, until now she has shown in the enthusiasm of her youth that she can stride across the Atlantic. It will be our duty in the following chapter to indicate how she came to be treated with entire confidence, and to take her part in the regular routine of the world's work.

CHAPTER IV

THE INAUGURATION OF THE LINER

It was not to be thought that the achievements which we chronicled at the end of the preceding chapter would remain without their immediate results. If such small vessels as the *Sirius*, propelled by steam, could cross the Atlantic and return safe and sound; if still more easily the *Great Western* had been able to perform the feat and to show a substantial return on the capital laid out, surely there was an assured future for steamship enterprise. "What man has done, man can do," is an old proverb, the application of which has led to the founding of those mighty, excellently equipped fleets which have transformed the trackless, desolate North Atlantic into a busy thoroughfare, along whose fixed routes every day of the year are carried thousands of passengers and tons of merchandise from one continent to the other. Although nowadays there is scarcely a corner of the world to which a regular line of steamships does not run, yet it is the North Atlantic that has always been the scene of the greatest enterprise in steamship development. We could find plenty of reasons for this if we cared to inquire into the matter. It was not until the advent of the transatlantic steamship that all the possibilities of the Tudor voyages and discoveries began to be appreciated fully. A continent, like a single country, flourishes not merely by its produce of wealth, but by its exchange thereof. So long as it is separated by thousands of miles, every fathom of which is fraught with danger and has to be traversed by

sailing ships whose arrival may be weeks or months late, which may, in fact, never arrive at all, a tight restriction is kept on the exchange of wealth; stagnation ensues, people travel as little as possible, and remain ignorant in their own narrow provincialism. Whereas, to-day, they take every possible advantage of travel, of voyaging the world over, not merely to exchange wealth but to exchange ideas, to add to their knowledge, to wipe out their provincialism.

For this we must thank the coming of the liner.

It was that memorable year of 1838 that set all this going. Impressed by the obvious advantages which the steamship now showed for speed and reliability, the Lords Commissioners of the Admiralty, to whose care was then entrusted the arrangement of postal contracts, saw that those ancient "coffin brigs" were doomed. Their lordships forthwith issued circulars inviting tenders for the carrying of the American mails by steamers. It happened that one of these circulars fell into the hands of Samuel Cunard, a prominent merchant of Halifax, Nova Scotia. He had been anything but disconnected with shipping, for he was the owner of a number of sailing ships trading between Boston, Newfoundland and Bermuda, and was agent at Halifax for the East India Company, who in their time owned some of the very finest sailing fleets that ever put to sea. And this Samuel Cunard had been one of the shareholders of that first *Royal William* which crossed in 1833 from Pictou, Nova Scotia, to the Isle of Wight. A man of energy and enterprise, he had already realised that a line of steamers connecting the two continents ought to become something real, and he had sufficient foresight to see that this was an opportunity which does not occur many times in a generation.

Having made up his mind, after reading this circular, the next thing was to find the money. In Halifax it was not possible to raise the required capital, so he crossed forthwith to London. But London is not always ahead of the provinces, and the wealthy merchants declined to show their financial interest in the scheme. Therefore, armed with a letter of introduction from the secretary of the East India Company, Mr. Cunard travelled north to Glasgow, to Mr. Robert Napier, whose name we have already mentioned as a great Clyde shipbuilder and engineer. Napier promised to give him all the assistance possible, and introduced him to Mr. George Burns, and the latter, in turn, to Mr. David MacIver. Both had an expert knowledge of the shipping business, and to a Scotch shrewdness united wide experience and ability to look ahead. As a result, within a few days the necessary capital of £270,000 had been subscribed, and an offer was made to the Admiralty for the conveyance of Her Majesty's mails once a fortnight between Liverpool and Halifax and Boston. But the owners of the *Great Western*, with a ship all ready for the work, were not going to let so fine a chance slip by without an effort. They, too, competed for the privilege, though eventually the organisation with which Cunard was connected was considered to have made the more favourable tender. This was accepted by the Government, and a contract for seven years was signed. The three enterprisers went to their posts—Cunard to London, Burns to Glasgow, and MacIver to Liverpool, but before matters had taken a final shape the Government required that the service was to be carried on by four ships instead of three, that fixed dates of sailings should be adhered to, and in consideration of all this a subsidy was eventually granted to the steamship owners of the sum of £81,000 per year. The cor-

poration which we now know as the Cunard Company was then called the British and North American Royal Mail Steam Packet Company, and they proceeded to get in hand the building of those first four steamers of which the *Mauretania* and *Lusitania* to-day are the lineal descendants. These four, then, were respectively the *Britannia*, the *Acadia*, the *Caledonia*, and the *Columbia*. They were all built of wood, all propelled by paddle-wheels, specially adapted for the transport of troops and stores in the event of war, with an indicated horse-power of 740, accommodation for 115 cabin passengers, a cargo capacity of 225 tons, while their dimensions and tonnage differed but slightly the one ship from the other. Their speed averaged 8½ knots per hour on a coal consumption of thirty-eight tons a day, the engines in each case being not unnaturally made by that Robert Napier who had by his introduction done so much to bring the formation of this company to a practical conclusion. These vessels were built on the Clyde by four different builders in the year 1840, but the *Britannia* was the first that was ready for service, her measurements being 207 feet long, 34 feet 4 inches wide, and 22 feet 6 inches deep, with a tonnage of 1,154.

Before we go on to outline the marvellous growth which has been seen under the Cunard Company's flag, whose history is practically a history of the Atlantic liner, varied here and there by the happenings which other rival companies have brought about, it is both curious and amusing to append the following letter, which has only quite recently been made public, and which will surprise many of those who here read it. It is evidence of the remarkable speed at which events may happen, and men's minds adapt themselves to newer conditions. Although Samuel Cunard was part owner of the first *Royal William* in

1838, and already three years earlier had thought over the idea of starting a line of Atlantic steamers, yet it will be seen that towards the end of 1829 he was not favourably inclined to the project. Having in mind all that the Cunard Company has done towards the inauguration of the liner, her continuous improvements, her safety and her efficiency, it is instructive to read the reply which was sent at this time to Messrs. Ross and Primrose, of Pictou, Nova Scotia, who had written to Cunard and Company in regard to steamship establishment:—

"Dear Sirs,—We have received your letter of the 22nd inst. We are entirely unacquainted with the cost of a steamboat, and would not like to embark in a business of which we are quite ignorant. Must, therefore, decline taking any part in the one you propose getting up.—We remain, yours, etc. S. Cunard and Company.

"*Halifax*, October 28th, 1829."

The above letter is now in the possession of Mr. John M. Ross, of Pictou.

But to return to the first sailing of the new company: the *Britannia* started the mail service in no conventional manner. Not merely was she to throw time-honoured custom to the winds by carrying the mails by the help of steam, but she dealt another blow to sailor-conservatism by setting forth on her maiden voyage on a Friday, which also happened to be the fourth of July, a day commemorative of another kind of Independence. Of course, the old-fashioned prophesied that so flagrant a disregard for superstition would spell disaster; but somehow the *Britannia* managed to arrive quite safely at Boston, on July 18th, 1840, after a voyage of just eight

hours beyond a fortnight, though she had touched at Halifax after eleven days, four hours. The citizens of Boston celebrated the event with banqueting and wild enthusiasm as the forging—shall we not say?—of the first of those stronger links which were to bind the two countries more closely and more securely together. Four years later, one bitter February, when this same *Britannia* was hemmed in, icebound in Boston harbour, the same enthusiasts liberated her by cutting a canal seven miles long and a hundred feet wide through the ice, and this entirely at their own expense.

Facing page 102 will be seen an illustration of a model of this *Britannia*. Old paintings show her rigged as a barque, with a couple of ship's boats in davits on either side, and another hung over the stern in a manner that will be familiar to those readers who have seen the American sailing schooners, and some of the Norwegian craft. The space for boilers and engines still causes that long gap between the fore- and mainmast that we mentioned earlier. The square stern, the old-fashioned bows, and her lines generally, show that this first Atlantic liner was hardly a thing of beauty, if even she is to be remembered for ever as the first of a new series. Her paddle-wheels were 28 feet in diameter, and had 21 floats, which measured 8 feet by 2.8 feet. The mean draught of this little ship was 16.8 feet. Her engines were of the side-lever type, of course, the making of which Napier understood so well. Steam was generated in four boilers with twelve furnaces, and there were two cylinders. As we have already dealt with the working of these engines we need do little more than ask the reader to turn to the next page, where he will find a sectional model of an engine very similar to that which was installed in these first four Cunard liners. The non-technical

The contract was for ten years, and to take effect from December 1st, 1841. The fourteen ships were all named after British rivers, and many readers will be aware that this custom of the company has continued ever since, although in some cases the names of foreign rivers have also been thus employed. Some of these vessels were built at Northfleet on the Thames, others (including the *Teviot* and *Clyde*) were built at Greenock, others at Dumbarton, Leith, and Cowes. The Lords of the Admiralty stipulated that the vessels should be built under their supervision, and a naval officer was put in charge of the mails on each steamer, and carried out a sort of supervision of the ship's affairs, a boat's crew being always at his service when the mails were being taken aboard or disembarked. The illustration facing page 112 shows the launch of the *Forth* at Leith in 1841. This picture, which is taken from a contemporary painting, is worthy of perusal, as showing the close resemblance between the mercantile marine and naval architecture of the period. Strength rather than slim beauty, massiveness rather than fineness, formed the keynote both in the steam and sailing ships of that time. In the same year had already been launched the *Thames* from Northfleet, and in the following year that vessel inaugurated this new service, setting forth, like the older packets, from Falmouth. The voyage from there to the West Indies took about eighteen days, but exceptional runs were done in seventeen days.

This new steamship departure was an undoubted success, and the Admiralty admitted that even the Government, with all its naval resources, could not have succeeded so well as this private company in getting together and ready for sea in so short a time so many large and well-equipped new steamers. Financially this meant a very large outlay, and there was not

much less than a million of money expended on this first fleet. It should be stated, however, that the Government subsidised the concern by a grant of £240,000 per annum. Presently Falmouth gave way to Southampton as the headquarters of the Royal Mail fleet. To-day there are so many big liners calling at the Hampshire port, and there is at all times of the day so continuous a procession of all kinds of large steamships, that it is difficult to realise that in those days this was comparatively a small port.

It was only natural that, as soon as ever the West Indian service should have proved itself successful, a branch should be extended to the South American Continent. In 1846, therefore, the company organised a means of transit by mules and canoes across the Isthmus of Panama, which were in 1855 superseded by the Panama Railroad. Although we are departing from our historical sequence in the development of the steamship, it is convenient here to sketch very rapidly the progress of the Royal Mail Line farther still, for the evolution of a steamship company is not necessarily that of the steamship. A small company may be famous for having one or two ships that are always the last word in modern shipbuilding and marine engineering; a large company may possess a considerable aggregate of tonnage, but its ships may be behind the lead of others in improvements. For the moment we are considering the enterprise which enabled the early steamships to penetrate to distant, over-sea territories where the Elizabethan sailors had gone in their slow-going ships scarcely three centuries before.

In 1851 the Royal Mail Line service to South America began, and about 1869 those steamers which had stopped short at Brazil, and served the Argentine by transfer, continued

LAUNCH OF THE "FORTH" (1841).

By permission of the Royal Mail Steam Packet Co.

THE "WILLIAM FAWCETT" AND H.M.S. "QUEEN" (1829).

From the Painting by Frank Murray in the possession of the Peninsular & Oriental Steam Navigation Co.

their voyage to Buenos Ayres. In the course of time it was only to be expected that the heavy subsidy should be reduced. It dwindled down to £85,000 a year, and was finally allowed to vanish altogether as recently as June, 1905. Since then the Royal Mail Company has extended its West Indian service to New York via Jamaica. During the Crimean War some of the vessels of this line did good service as transports, and even more recently still during the South African War. It was on one of the vessels of this line that, during the American Civil War, an incident occurred which was of international importance. The ship which was brought so prominently into notice was the *Trent*, that had been launched at Northfleet. Some readers will doubtless remember that Messrs. Slidell and Mason were forcibly taken from this vessel by a Federal man-of-war, and that Lord Palmerston, by his action in the matter, set forth that valuable doctrine, still recognised, that an individual on board a British ship is as safe from foreign interference as if he were on British soil.

It was in 1840, also, that the Pacific Steam Navigation Company was granted its charter, and its history is, so to speak, a complement of that of the Royal Mail Company.* After the latter had extended its service to the Isthmus of Panama, and established a means of transit across to the western coast, it was evident that the Pacific littoral was ready for the steamship, and this the Pacific Steam Navigation Company now supplied. In the olden days the sailing ship had been the only means of doing this, but that meant braving the terrors of Cape Horn, as many of the surviving sailing ships do to this day. But the enterprise of the Royal Mail Line on the one side of the narrow neck separating North from South

* The Royal Mail Co. has now absorbed the Pacific Steam Navigation Co.

America, and the co-operation of the Pacific Steam Navigation Company on the other, together with the intervening land-journey, brought the inhabitants of the Southern Pacific much nearer to Europe. The Panama Canal, which is promised for opening in 1915, was thus foreshadowed. Sending round its two steamers, the *Chile* and *Peru*, to the west coast, the Pacific Company opened up a new sphere of commerce, and these two steamships were the very first steam-propelled craft that ever passed through the Straits of Magellan.

The foundation of the Peninsular Company dates back as far as 1837. Even a year or two before then its ships had commenced running to the Peninsula, but at the time mentioned a regular service of mail packets from London to Lisbon and Gibraltar was instituted. Here again we find the existence of a contract between the Admiralty and a steamship company for the carrying of the mails, but it was not until 1840 that the line was extended to Malta and Alexandria, and was incorporated by Royal Charter under the now well-known title of the Peninsular and Oriental Steam Navigation Company, with a view to carrying on operations in the Far East. The lower illustration facing page 112 shows the first steamship owned by the Peninsular Company, a little paddle vessel of only 209 tons. This was the *William Fawcett*, which was built in the year 1829. She measured 74 feet long, only 16 feet wide, developed 60 horse-power, and was engaged in the trade between England, Lisbon, and Gibraltar. But the first steamer which the newly incorporated company dispatched to India, via the Cape of Good Hope, was the *Hindostan*, a vessel of 1,800 tons, and 500 horse-power. She began her voyage from England in September, 1842, and her departure was a memorable event when we consider all that was destined

to follow therefrom, and how certainly it meant the ending of the careers of those fine East India sailing ships which had been brought to such a high state of perfection ere steam had appeared on the sea. The *Hindostan* was a three-masted vessel with a long bowsprit, "steeved" at a big angle, setting yards on her fore-mast for fore-sail, topsail and t'gallant, while her main and mizen were fore-and-aft rigged. She is interesting as having not one but two funnels, the first being placed very far forward, just abaft the fore-mast, whilst the other was immediately in front of the main-mast. The distance between the two funnels was great, for the purpose already indicated. The *Hindostan* was followed by other steamers, and in 1844 the P. and O. Company undertook a mail service between England and Alexandria, and so from Suez to Ceylon, Calcutta, and China.

Of course, as yet, there was no Suez Canal, so that, in a manner similar to that across the Isthmus of Panama, an overland route had to be instituted for passengers, cargo, and mails across the Isthmus of Suez. The P. and O. Company had, then, to land their passengers at Alexandria, and just as canoes and mules had to be employed in America, so boats and camels were requisitioned in Africa. But it was a complicated journey, for this "overland" route was mostly an over-water route. By means of the Mahmoudieh Canal the passengers and goods were sent from Alexandria to the Nile, whence they proceeded by steamer to Cairo. From there they travelled through the desert to Suez. Three thousand camels had to be employed for transporting a single steamer's loading; every package had to be subjected to three separate transfers, and the inconvenience was indeed considerable. But for nearly twenty years this system continued.

Steam communication was inaugurated by the company with Australia in 1852, by means of a branch line from Singapore, and two years later the service between Suez and Bombay was absorbed by the P. and O. Company. This had been retained hitherto by the East India Company in order to keep alive their navy. In 1869, came the opening of the Suez Canal, and it was essentially the steamship and not the sailing ship which brought this about, although the Suez Railway preceded the canal by ten years. It is not generally known, perhaps, that a continuous waterway had already existed long years before. In the times of the early Egyptians there had been a canal which connected the Nile with the Red Sea, so that ships could circumnavigate Africa and, returning by the Mediterranean, could come out through the Nile into the Red Sea again. But the Suez Canal had not been demanded so long as the steamship remained undeveloped, and even for some time after the traffic to Australia and New Zealand was principally carried on in those handsome clipper-ships which were representative of the finest examples of the sailing ship. It is only by means of the steamship that it is possible to bring across so many thousands of miles the great quantities of frozen meat and other perishable foods which now reach this country, and the Suez Canal certainly assisted to make this possible. Not merely did the steamship indirectly bring about the Canal, but the latter increased the steamship's sphere of usefulness.

About the time when the Suez Canal was opened the practical adoption of the compound engine was taking place in the mercantile marine. This idea had been introduced about 1856 by Messrs. Randolph Elder and Company, and had been installed in the ships of the Pacific Steam Navigation Com-

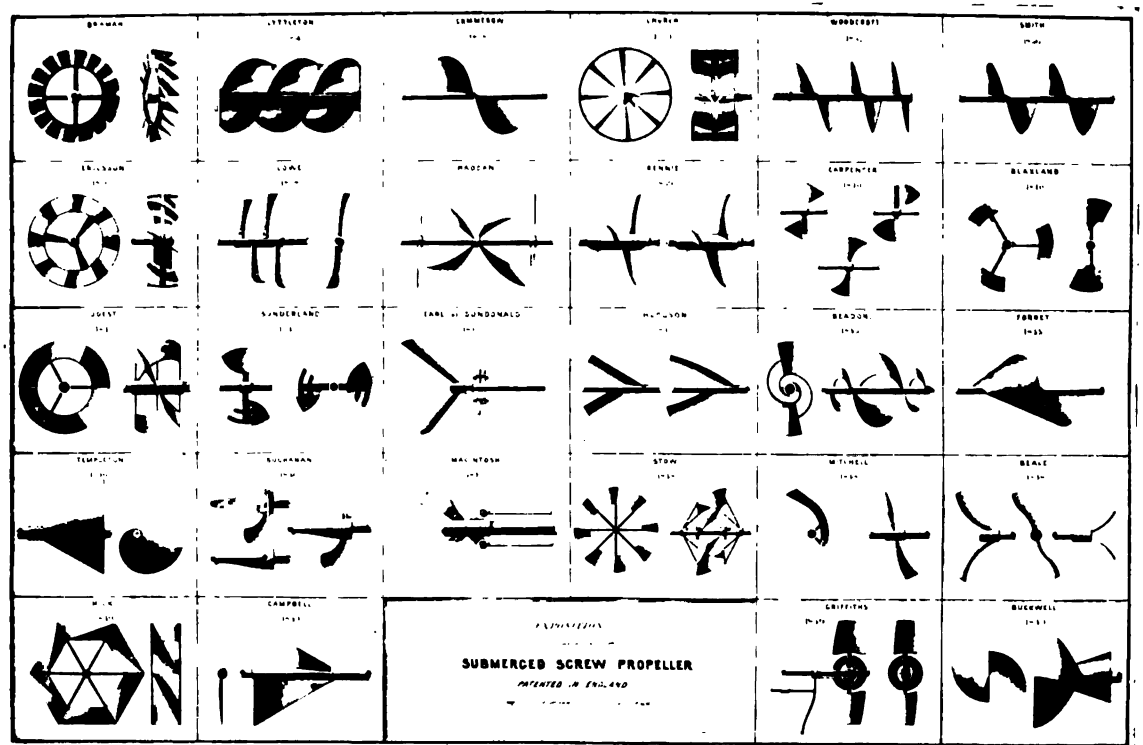
pany. In explanation of this system we may say at once that its great advantage lay in the fact that it reduced the coal consumption to just about half of what it had been hitherto in the most economical engines. The principle is based on the fact that steam possesses elastic properties which can be put to excellent use. Put simply, the compound engine allows the steam to enter one cylinder at high pressure, and, after it has moved the piston, escapes into one (or more) cylinders of larger size, where it does its work by direct expansion, and so much more work is done at little expense. The expression "triple expansion," which frequently confronts the reader interesting himself in steamships, simply means that the steam is expanded one stage further. Quadruple expansion is the same idea pushed still another stage. When about twenty years ago the triple expansion system was brought in, the steam pressures were increased from 125 lb. to 160 lb. per square inch, and so the coal consumption was reduced also. But the triple expansion had been preceded by the compound and the low pressure engine, just as it was followed by the quadruple.

The opening of the Suez Canal was not devoid of side issues, for it took away that monopoly which the P. and O. had enjoyed, since the world's steamships now poured in and began to go eastward and back again. There was difficulty with the Post Office, who refused to allow the Canal route for the conveyance of mails, on the ground that it was not so suitable as the Egyptian Railway, and it was not until 1888, when the charge for carrying the mails had been reduced by nearly £100,000 a year, that the accelerated mails sent via Brindisi were transferred to the Canal route, although the heavy mails had already been carried by it. But the

P. and O. were unlucky in another way. The *Mooltan*, their first ship to be installed with the compound engine, in 1860, had proved such a success that several other steamers of the line were thus fitted, but the result was disappointing. Although it was quite clear that this type of engine made for economy, yet it was found unreliable, and in some cases had to be replaced by less complex machinery.

We have now been able to see steamship lines established and sending their fleets regularly with passengers, cargoes, and mails to the uttermost ends of the earth, and we have been able to look ahead a little so that we shall be free to concentrate our attention very shortly on that centre of steamship activity the North Atlantic. Between 1840 and 1860 the Cunard Company had practically a monopoly of the Atlantic trade. For a time the American clippers hung on, but as they had ousted the old brigs, even the fastest sailing vessels were replaced by the steamship. From 1850 to 1858 there was, indeed, some opposition from a steamship company called the Collins Line, which had been subsidised by the American Government. This competition was very keen, for both lines were compelled to put forth the best steamers they could, but in the end the Collins Line withdrew from the contest.

But there was now another force coming in, which was to entirely alter the character of the liner. Let us trace the evolution of the screw propeller, which has completely banished the old-fashioned paddle-wheel from its place in the ocean-going ship, and is rapidly having the same effect in cross-Channel steamers. We saw that away back in 1804 John Stevens had crossed the Hudson in a little ship that was driven along by a screw propeller, but it was not until



DESIGNS FOR SCREW PROPELLERS PRIOR TO 1850.
From the Drawing in the Victoria and Albert Museum.

the year 1836 that the screw was re-introduced. In this year John Ericsson, a Swedish engineer, obtained a patent for his invention which consisted of two drums, on whose exteriors were seven helical blades, the interior of each drum having the three blades which formed the radii of the circle. Both these drums worked on one axis, and were placed behind the rudder, and not in front of it as is the modern propeller. If the reader will turn to the plate facing page 118, he will see this at the beginning of the second line to the left. The drums were made to work in opposite directions, the object being to avoid loss due to the rotary motion already remaining in the water discharged by a single screw.

Ericsson applied this invention to the *Francis B. Ogden*, which was built in 1837. She was 45 feet long, and was driven by a two-cylinder steam engine with a boiler pressure of 50 lb. The result of the experiment showed that she could tow a vessel of 630 tons burthen at 4½ knots against the tide. The following year a larger vessel, the *Robert F. Stockton*, was built by Laird Brothers, and attained a speed of thirteen knots on the Thames, with the tide in her favour. Afterwards she crossed the Atlantic, but under canvas, and was turned into a tug as the *New Jersey*, for work in New York waters. The illustration facing page 120, which has been lent by Messrs. Cammell, Laird and Company, Limited, of Birkenhead, shows her rigged as a topsail schooner under sail and steam. Her measurements were 63.4 feet long, 10 feet beam, 7 feet deep, with a register of 33 tons, and engines of 30 horse-power. Although she was the first screw steamer to cross the Atlantic, yet her voyage is interesting rather as a fairly daring trip of a small sailing ship than as proving the reliability of the screw propeller.

But at the same time that Ericsson was working at his idea, Francis Smith, an Englishman, who was afterwards knighted, was also engaged at the same problem, though his method of solution was of a different nature, as will be seen by a reference to the last illustration on the first line of the plate facing page 118. His patent was granted in the same year as Ericsson's, and was tried with success the year after on the Paddington Canal. Smith was a farmer at Hendon, and had already experimented with a model driven by clockwork on a farm pond, just as Fulton had carried out his early experiments with a clockwork model in a tank. The next step was to repeat the experiment on a six-ton boat which was driven by a steam engine, the propeller being, like those of the modern aeroplanes, of wood. It was while thus experimenting that an interesting accident happened, for about one-half of the screw thus shown in the illustration was broken off, and to everyone's surprise the boat instantly began to leap forward at a quicker speed. Later the boat was fitted with a screw having one turn instead of two, and made of metal instead of wood, and in this small craft Smith cruised as far as Folkestone. Her speed was 5½ knots.

From these satisfactory results made by the six-tonner *Francis Smith*, sufficient interest was aroused to form a syndicate to test the proposition commercially, and to purchase Smith's patents. The result was that the *Archimedes*, of 240 tons, was launched from Limehouse in November, 1838, and fitted with Smith's screw. It must be recollected that the same old obstinacy was still very much alive that had hindered other inventions connected with the ship, and it was not until the *Archimedes* had toured round Great Britain, and steamed across the Bay of Biscay and back without mishap, that people

THE "ROBERT F. STOCKTON" (1838).

Photograph supplied by Messrs. Cammell, Laird & Co., Limited, Birkenhead

THE "ARCHIMEDES" (1839).

From a Contemporary Print.

began to believe in this new method of propulsion. To-day everyone knows how entirely dominated by the screw the steamship now is, and that the paddle-wheel belongs almost exclusively to the excursion passenger steamer.

Of course, Smith's propeller was very different in expression from the shape in use to-day, but the last word as to the ideal shape and size of the screw has even yet to be said. It would be interesting to detail all the attempts which have been made by different inventors to deal with the screw, but their name is legion, and our space will not permit. An idea, however, can be obtained of the various forms of screw propellers patented in England before 1850 from the plate facing page 118, to which we have already called attention.

The lower illustration facing page 120, which is taken from a contemporary aquatint, shows the *Archimedes* on her voyage from London to Portsmouth in the year 1839, when she attained a speed of eight knots against both wind and tide. Facing page 122 is reproduced a model of her stern framing before being planked up. As a further test of this screw idea Wimshurst, who had built the *Archimedes*, launched the *Novelty* in 1839, a much larger vessel than her predecessor. The *Novelty* will be seen in the next illustration, and in her we see the "screw" vanishing and becoming more assimilated to the modern propeller. Originally the corkscrew shape entitled it to be called a screw; but the evolution of time and experience has now considerably altered this. It will be noticed that in the *Archimedes* the screw is a little distance away from the stern-post, but as seen in the *Novelty* the propeller is put right close up against it. This *Novelty* was the first cargo steamer fitted with a screw, and made her inaugural trading voyage from London to Constantinople and back

with entire success. She is interesting also as having been the first ship to be fitted with an iron mast. This material was employed for the mizen, the other masts were of wood; her rig was that of a barque. For some years after the introduction of the screw, and so long as sails were still retained as auxiliaries, there had to be some means of overcoming the resistance of the screw when not in use and the ship was proceeding under sail power. This was done either by fixing the blades so that they caused the minimum drag, or by lifting the screw into a well. The *Novelty* lifted hers on deck over the quarter by means of davits. This arrangement will also be seen in the illustration. This idea is now obsolete, since sails are but rarely employed as auxiliaries.

Now the introduction of the propeller was not so simple an event as the reader might imagine. Ordinarily, one is tempted to argue that it was merely a case of putting the power aft instead of at either side, as in the use of the paddle-wheels. But, in fact, the introduction of the screw opened up a new set of problems connected with ship design. In the early days the design of a ship's stern, both in the sailing ship and the steamer, was badly neglected. Later on the improved lines of the clipper sailing ships certainly did much to improve matters. I referred at the beginning of the previous chapter to the manner in which a vessel going ahead moves the water in which she floats, and how the eddies round the stern impede her advance. Now when a propeller revolves, much of its power is, even nowadays, wasted by what is called "slip"—that is to say, by the yielding of the water so that the screw does not progress to the full extent of its "pitch." (The "pitch" of a propeller is the amount of distance which is represented by one whole turn of the thread. We could

STERN OF THE "ARCHIMEDES.

From the Model in the Victoria and Albert Museum.

THE "NOVELTY" (1839).

From the Model in the Victoria and Albert Museum

measure, for instance, the "pitch" of a corkscrew by the distance which it would penetrate in a cork.) Even after years of experiments and improvements the wake at the end of a steamship tends to reduce the speed of the water past the propeller, but when first the screw experiments were conducted the design of the afterbody of a ship's hull was so carelessly considered that the "slip" of the propeller was considerable. There is also to be taken into account the fact that by the rounding in of the "stream lines" at the stern the vessel receives a pressure which helps her forward. When, however, a propeller is added to a ship and set in motion it disturbs this helping-forward movement, and in a ship fitted with only a single screw this disturbance is even greater than in a twin-screw steamer, because the latter has her propellers placed well out, away from the hull. We need not here pursue the subject further; it is enough now to show that every improvement in the steamship began a new chapter of problems, introduced difficulties that could never have been anticipated, which time and patience alone can solve satisfactorily.

And so we come to the construction of the *Great Britain*, of which the model is illustrated opposite page 126. Let us recollect that it was only in 1836 that the little six-ton launch *Francis Smith* had been built, and that it was only three years later that the *Archimedes* showed by her successful voyages that the screw method of propulsion was no fanciful, impracticable theory. In this same year, 1839, there began to be built a still more wonderful screw steamer. The Great Western Steamship Company had already been so satisfied with the *Great Western* that they believed that a far larger ship would be even still more profitable. Therefore, Brunel was again consulted,

and he reported that already the furthest limit of long ships built of wood was reached. There was no alternative but to construct her of iron, for the reasons that I explained some time since. Iron had already been used in ship-building for barges and also for steamboats, but on no large scale. Aaron Manby, in conjunction with Charles Napier, had built the first iron steamboat as far back as 1821. This ship had been conveyed in sections from Horseley, where she was made, to the Surrey Canal Dock, and there put together. After being tried on the Thames on May 9th, 1822, she steamed away the next month with Napier in command, and Manby as engineer, arriving in Paris on the eleventh of the same month. She was thus not merely the first iron steamship, but the first iron ship that ever put to sea. For the next twenty years she continued to ply on the Seine. Napier was the financier of the attempt to promote iron steamers on the French river, but by 1827 the slump in the steamboat had taken an acute form, and he was left a comparatively poor man. But in 1832 the *Lady Lansdowne* was built by John Laird of Birkenhead for the City of Dublin Steam Packet Company, and she was the first iron steamer constructed with the intention of performing sea-service. She was a paddle-boat, and measured 133 feet long, 17 feet wide, with a tonnage of 148 and a nominal horse-power of 90. Later still the *Robert F. Stockton*, to which we have alluded, was also of iron.

But the *Great Britain* was to be 322 feet long, with a beam of 50½ feet, and a displacement of 3,618 tons, with a cargo capacity of 1,200 tons, able to carry also 1,000 tons of coal, and 260 passengers. To build such a big lump of a boat as this was to be a very grave undertaking indeed. In fact, no contractor could be found who would undertake the con-

struction of the ship or her engines. She was something out of the unknown; there were no data upon which to base calculations. Brunel, therefore, made out the designs and the Great Western Company with great daring proceeded to lay down plant for building her themselves at Bristol. This was in 1839. It was intended to give her the usual paddle-wheel engines, but the *Archimedes* arrived at this port, and the success of her screw propulsion caused Brunel to modify his designs so that the *Great Britain* should become not only the largest iron ship ever built, but the largest screw steamer.

It was originally intended to name her the *Mammoth*, but she had better been called the *White Elephant*, for all the use she was afterwards to her owners. Her rig was like nothing afloat, and the vocabulary of nautical terms contains no adequate description. From our illustration it will be seen that she had six masts. On all except the second she carried fore-and-aft canvas, but this second mast carried two yards and square sails. Forward she had a bowspirt and triangular headsails. In sail area alone she carried 1,700 yards of canvas, and in length the hull was 100 feet in excess of the largest line-of-battleship afloat. She was actually floated on July 19th, 1843, but it was not until December of the following year that she was able to enter the river, owing to the delay in the alteration of the dock. In the meantime her engines had been put aboard, and on July 26th, 1845, after trips to London and Liverpool, she left the latter port with sixty passengers, and 600 tons of cargo for the Atlantic run. She arrived in New York after a fifteen days' passage, with an average speed of 9½ knots. On the homeward voyage her best day's run was 287 miles. The illustration facing page 126 is from a model of her six-bladed propeller, with

which originally she was fitted; but on one of her voyages she had the misfortune to break this and proceeded to Liverpool under her canvas. A new propeller was then fitted which had but four blades, but later on she again resorted to the original number. She continued her Atlantic voyages until 1846, when she ran ashore off the Irish coast in Dundrum Bay during the month of September, and remained for eleven months exposed to the terrible wintry weather; but Brunel had a wooden breakwater, loaded with stones, constructed round her, and she was eventually re-floated and taken to Liverpool, and though her bottom was naturally considerably damaged, yet the mere fact that she had been able to survive at all showed that confidence might be placed in iron as a material for ship-building. But by this time her owners had had enough of her, and she was sold for less than one quarter of the £100,000 she had cost. After alterations to her rig and her engines, she was employed in the Australian trade. She was next relieved of her engines, and turned into a sailing vessel, and then used as a coal-hulk off the Falkland Islands. Finally she was broken up at Barrow.

But apart from her size, the *Great Britain* possessed other novel features which are worthy of notice. We have already remarked that as the length of ships increased, so did the longitudinal strain, and new methods had to be devised in order to overcome this. The *Great Britain* was specially strengthened longitudinally, and furthermore she was divided into five water-tight compartments. The original purpose of transverse bulkheads was that if a vessel were holed by collision or grounding, or—in the case of naval vessels—pierced by shell, she might yet remain afloat. Nowadays they do more than this, for, when carried up to the strong deck,

THE "GREAT BRITAIN" (1843).

From the Model in the Victoria and Albert Museum.

PROPELLER OF THE "GREAT BRITAIN."

From the Model in the Victoria and Albert Museum.

they add to the longitudinal strength of the ship. The *Great Britain* also possessed another novelty, in bilge keels, which extended for about one-third of her length. The object of these, which are so well-known a feature of modern steamships, was to lessen rolling. Her bulwarks consisted of iron rails with netting running round the ship. Here, again, was a new departure. In the older ships the heavy wooden bulwarks were a relic of the days when the guns were sheltered behind them; but from the view of seaworthiness they were really a false safety. If a heavy sea were shipped, the water was held in and not allowed to get away easily; in the case of the *Great Britain* the water could escape just as quickly as it came aboard.

Facing page 128 will be seen a reproduction of a model of the *Great Britain's* engines, as originally placed in her before she ran ashore. Steam was generated in a double-ended boiler. The nominal horse-power was 1,000, but twice that amount could be obtained, and a speed of over 12 knots. There were four direct-acting cylinders—of which two will be seen in the foreground of the illustration—placed as low down in the ship as possible. The early engines which were used for the screw did not drive the latter directly, and on reference to the illustration it will be seen that in the centre of the crank shaft was a drum, which was connected with another drum just below it on the propeller shaft by means of four chains.

When referring to the side-lever engines in a former chapter, I drew attention to the fact that in spite of their virtues they had the great drawback of taking up a great deal of space. The second illustration facing page 128 represents an attempt to overcome this disadvantage. As will be seen on examining

the lower part of the engines, the lever has now become very small in size. It will be noticed that there are two inverted cylinders, whose piston-rods are connected by a cross-head, the latter being guided by lever parallel movement, and from it the power was conveyed by means of a connecting rod to the crank on the paddle-wheel shaft. The connecting rod can be seen between the two cylinders in the illustration. These engines were made in 1848 for the *Helen McGregor*, a paddle-steamer engaged in the Hull-Hamburg trade. She was of 578 tons, and was one of the largest ships of her class.

It was not until 1852 that the Cunard Company were so thoroughly convinced of the capabilities of either iron shipbuilding or the screw propeller as to give both a trial. Four iron screw steamers were then built, and these were the first owned by this line which were fitted with accommodaton for emigrants. The next year six more iron screw steamers were added, and connection formed with the chief ports of the Mediterranean; and when the Crimean War broke out a number of the Cunard ships were employed as transports. But from one reason and another the screw propeller had not found general favour among passengers. The vibration it caused, its unpleasant "racing" in bad weather, and the new motion as compared to that of the old paddle-wheel, allied to the usual obstinate temperament, showed that the earlier type had still to be retained for a while. Following on the medieval custom, the stern of these early steamships was still regarded as the place of honour, and the saloon passengers were accordingly placed abaft the machinery, which was amidships. Thus placed, the traveller was doubtfully privileged, for the close proximity of the propeller made life on shipboard exceedingly trying to the nerves, and there were

ENGINES OF THE "GREAT BRITAIN."

ENGINES OF THE "HELEN McGREGOR."

From the Models in the Victoria and Albert Museum.

many who, having voyaged in the old ocean-going sailing ships, looked back with mixed feelings to the longer but less nerve-racking journeys. The strain on the early screw engine was very considerable when the vessel was pitching fore and aft into the Atlantic seas. Being of comparatively small size, its movements in such circumstances were far more lively than in a modern, lengthy liner, which is able to stretch over a longer span. Consequently, as the bow came down into the sea and the stern rose out, the propeller was much more prone to race wildly, and the gearing, such as we saw in the engines of the *Great Britain,* was not infrequently unable to endure the terrible strain to which it was put. It was for this reason that the screw engines were afterwards made direct-acting.

The Cunard Company decided to build their next ship of iron, but with paddle-wheels. This was the *Persia,* launched in 1856, a vessel of 3,300 tons burthen, with accommodation for 250 passengers. But she was even surpassed by the *Scotia,* which was built in 1862, and is interesting as being the last and the finest paddle-ship which was ever made for their Atlantic service. An illustration of this vessel will be found opposite page 130. She was fitted with the greatest luxury of the time, to carry 275 cabin passengers, had seven water-tight compartments, and a double bottom, so that even if she should have had the bad luck to run ashore she would still most probably be able to endure. Nowadays most steamships are fitted with this excellent arrangement, which was first adopted in the *Great Eastern,* through the ingenuity of Brunel, to which we shall refer presently. But the *Scotia* turned out to be also a fast boat, and materially altered the time spent in crossing the Atlantic; she lowered the record to just two hours under

the nine days. Her engines were of the familiar side-lever type, and were the finest examples of their kind that were ever made. The cylinders were 100 feet in diameter, and steam at 20 lb. pressure was supplied by eight boilers with forty furnaces, the speed attained being 18¼ knots per hour; her daily coal consumption was 159 tons. She could carry 1,800 tons of coal, and was exceedingly strongly constructed. We can obtain some idea of those paddle-wheels shown in the illustration when we remark that they were no less than 40 feet in diameter. She was afterwards turned into a "telegraph" ship for use in cable-laying, and her paddles changed for twin screws. It was not until about 1896 that her water-tight bulkheads were put to practical use; for as the result of an explosion on board of vapour from spirit her bow was blown out of her, and the water began to rush in. Her collision bulkhead was also damaged, but happily the second bulkhead saved the ship from foundering.

Turning our attention away from the North Atlantic for a while, we shall be able to see that steamships on other routes were now fast passing from the olden types, when designers and builders were working with only a minimum of data on which to base their achievements. We have already referred to the highly important knowledge which was gradually being obtained concerning the relations between the hull of a ship and the water in which she is floated. One of the greatest authorities on this subject about the middle of the last century was John Scott Russell, who worked out a theory regarding the resistance of the ship passing through the water. He it was who contended that the hull should only move the water out of the way sufficiently to allow the widest section of the ship to pass through, and to do this in such a manner

THE "SCOTIA" (1862).

From a Painting. By permission of the Cunard Steamship Co.

THE "PACIFIC" (1853).

From a Painting in the Victoria and Albert Museum.

as should cause the least amount of friction and disturbance of the water, so that, when the ship was gone by, the particles of water should be restored to their original quietude. It is important to bear in mind that the design of a ship must be made with regard to the speed which it is intended to get out of her. Thus, it is now a well-known principle that to give a ship highly powerful engines so that she is forced beyond her proper speed only makes the waves diverge from the sides and waste themselves instead of travelling with the vessel and giving it a forward impetus.

The model of the hull in the illustration facing page 184 represents the steamship *Victoria*, which was built in 1852 of iron, and designed by those two great geniuses Brunel and Scott Russell for the Australian Royal Mail Steam Navigation Company. Even the least practised eye on looking at her lines can see that she possessed speed, and it was this ship that gained the £500 prize offered by the Colonies for the fastest voyage to Australia, her time from Gravesend to Adelaide being sixty days, including two days' delay at St. Vincent. The *Victoria* was designed as embodying the wave-line theory and for a speed of ten knots. It is not necessary to examine this model many moments before one realises how unmistakably the clumsy, ponderous hulls so characteristic of earlier years were now being replaced by sweet, graceful, non-resisting features. The hull of the *Victoria* was separated into a dozen water-tight compartments and displaced 8,000 tons, her length being 261 feet, with a breadth of 88 feet, or approximately seven beams to the length. She had a two-bladed screw, and when this was not in use, and the *Victoria* proceeded under sail-power alone, the propeller was fixed vertically. Thus arranged, the ship could sail $5\frac{1}{2}$ knots, but

it is interesting to remark that when the screw was allowed to revolve freely the speed of the ship was increased another couple of knots.

It was in this ship that a type of engine was fitted to which, so far, we have not referred. This was the oscillating kind, and was destined to become pretty well universal in paddle-ships, though not without serious opposition at one time. This type had been patented as far back as 1827, by Joseph Maudslay, and in the *Aaron Manby*, already mentioned, the machinery was of an oscillating nature, for which Manby had obtained a patent in 1821, but even farther back still—in 1785—William Murdoch had proposed the use of oscillating cylinders. It is only fair to Maudslay to say that he had independently worked out this arrangement, and so afforded yet another instance of the possibility, which I have enunciated before, of different inventors working at the same set of problems and bringing about a similar method of solution. In the accompanying illustration is shown Maudslay's original oscillating engine. In this type the cylinders, instead of being fixed, oscillate, and the necessity of the connecting rod is dispensed with, for the cylinder is placed immediately underneath the crank shaft, as a reference to the illustration will show. Each cylinder is mounted on trunnions in the same manner as a cannon, being placed at a point about the middle of the cylinder's length, so that it can swing, or oscillate, in such a way as to correspond with the arc which the crank makes in its movement. Thus there are both weight and valuable space saved. In the instance before us the condenser is placed between the two cylinders; the central trunnions communicate with the condenser, and the outside trunnions with the steam pipe. But Maudslay's engines did not at that time find the

MAUDSLAY'S OSCILLATING ENGINE.

From the Original in the Victoria and Albert Museum.

ENGINES OF THE "CANDIA."

From the Drawing in the Victoria and Albert Museum.

appreciation which had been hoped for, and it was not until 1838, when they were re-introduced by John Penn, that they received their full favour. We shall return to the oscillating type when we come to consider the *Great Eastern*. But we may remark that the interesting steamship illustrated opposite 130 was also provided with the oscillating pattern. This is the packet steamer *Pacific*, which was built in 1858 for the Mediterranean service, and is another example of a vessel constructed on the wave-line system. She was built of iron, and had nine water-tight compartments.

The *Pacific* was interesting in another feature, in that she generated her steam in four tubular boilers, each of which had five furnaces. Briefly the evolution of the boiler had been on this wise: As originally fitted in the *Clermont* and *Comet* it was simply a water-tank set in brickwork, and was nearly full of water, with the fire outside, or, to use the expression generally employed, "externally fired." In those days the pressure of the steam was not greater than the pressure of the air, which we saw to be 15 lb. to the square inch. Then came a modification of this in which the furnace was placed inside the boiler, the advantage being that, with the water all round, the latter could be the more readily heated. This developed into the marine "box" boiler, with internal flat-sided flues and furnaces. This type continued to be fairly universal until about 1845, but the utmost pressure of steam which these were capable of enduring was not above 35 lb. or thereabouts. But tubes instead of the flat flues began to be introduced about the year 1850, owing to the suggestion of the Earl of Dundonald, and these were to be of about double the diameter of those which had been common to locomotives for the previous twenty years. The pressure was soon raised considerably, but there was a strong

prejudice against using high pressures at sea, and the idea was not encouraged.

In the same year that the *Pacific* took the water was launched the *Himalaya*, of which a beautiful little model is here illustrated. She was built for the P. and O. Line. This fine ship-rigged steamship was constructed of iron at Blackwall in 1853, and in the following year was bought by the British Government and steamed away from Plymouth with soldiers for the Crimea. She was of 4,690 tons displacement, and in that year made a record run from Gibraltar at an average speed of 13½ knots. Originally she had been built for carrying both cargo and passengers, but now she is, or was, ending her sphere of usefulness as a coal hulk at Devonport. Her coal "endurance"—she could carry 1,200 tons—made her a valuable asset, and her six water-tight bulkheads rendered her still more efficient. As will be seen from the illustration, she had a single propeller, and this was driven by yet another type of engine, which we have now to consider. We refer to the vertical trunk engine. We shall be able to understand this better if we examine the illustration facing page 132, which reproduces a drawing of a similar type of engines installed in the P. and O. *Candia*, built a year later than the *Himalaya*. In the trunk engine the piston-rod was done away with, so that the connecting rod is attached directly to the piston within a trunk or tube. This trunk passes through a steam-tight stuffing-box in the cylinder cover, and is made wide enough to allow of the lateral vibrations of the connecting rod inside. As long as steam pressures did not exceed 35 lb. this proved to be satisfactory; but the friction of the stuffing-boxes when they became of large dimensions was a serious drawback. The *Candia*, for which

THE "VICTORIA" (1852).
From the Model in the Victoria and Albert Museum

THE "HIMALAYA" (1853).
From the Model in the Victoria and Albert Museum.

COASTING CARGO STEAMER (1855).
From the Model in th. Victoria and Albert Museum.

these engines were made, was a screw ship, and the cylinders were placed in a fore-and-aft position. By means of this type of engine, employing trunks, the height required was greatly lessened, and it was not necessary, as will have been noticed was essential in the case of the *Great Britain's* engines, that part of them should come up through the deck. Thus, the trunk type meant a saving of valuable space. Between the cylinders were arranged the condensers, which were of the jet type. We may stop to remind the reader that the condenser had been the invention of Watt, who had improved on the Newcomen engine not merely by covering over the top of the cylinder, but by condensing the exhausted steam in a separate vessel, called a condenser. This condensation he brought about by means of a jet of cold water, and the same principle was still employed in the *Candia*. Condensation having taken place, the water thus formed, together with any air which has got in, is then drawn off by the air-pumps, which will be seen in the illustration to be worked from an intermediate crank. It will be remarked on glancing at the left of the picture that the *Candia's* crank shaft was connected with the propeller shaft by means of spur gearing, which doubled the speed of the screw, and so of the ship, but yet allowed the actual engines to run comparatively slowly. This toothed wheel idea was a better method than that employed in the *Great Britain's* engines, though it was only just one stage better. There was a rooted objection in the early days of the screw to running the engines at a great speed, and thus it was only by some such means of gearing that the propeller was made to revolve quickly. In the course of time, when a wider experience and knowledge of engineering matters had been obtained, the gearing was done away with and the engines became direct-acting, and

so there ensued far less friction, an absence of complication, and less expense caused by gearing. At the same time the power obtained by the newer method became more direct.

A customary apparatus nowadays adopted for steamships is the surface condenser, and in the effort to increase the steam pressures this has been a potent factor. But it had already been tried by Watt, by David Napier, and re-introduced by Samuel Hall in 1881. The surface condenser consists of a number of brass tubes about three quarters of an inch in diameter, through which a stream of cold water circulates. This necessarily keeps the pipes cool, and thus condenses the exhaust steam which is thrown on to them from the cylinder; it is practically a kind of tubular boiler. Instead of the jet, as in the older form of condenser, it is the outside of the pipes which performs the office, and the air-pump does its work as before. The condensed steam is now available for feeding the boiler, and after being filtered the feed pump draws it into a heater and thence it is led into the boiler once more. If the reader will now turn to the illustration facing page 182 once more, he will see in the right hand of the picture that in the *Candia* the feed and bilge pumps were worked by small beams from an eccentric.

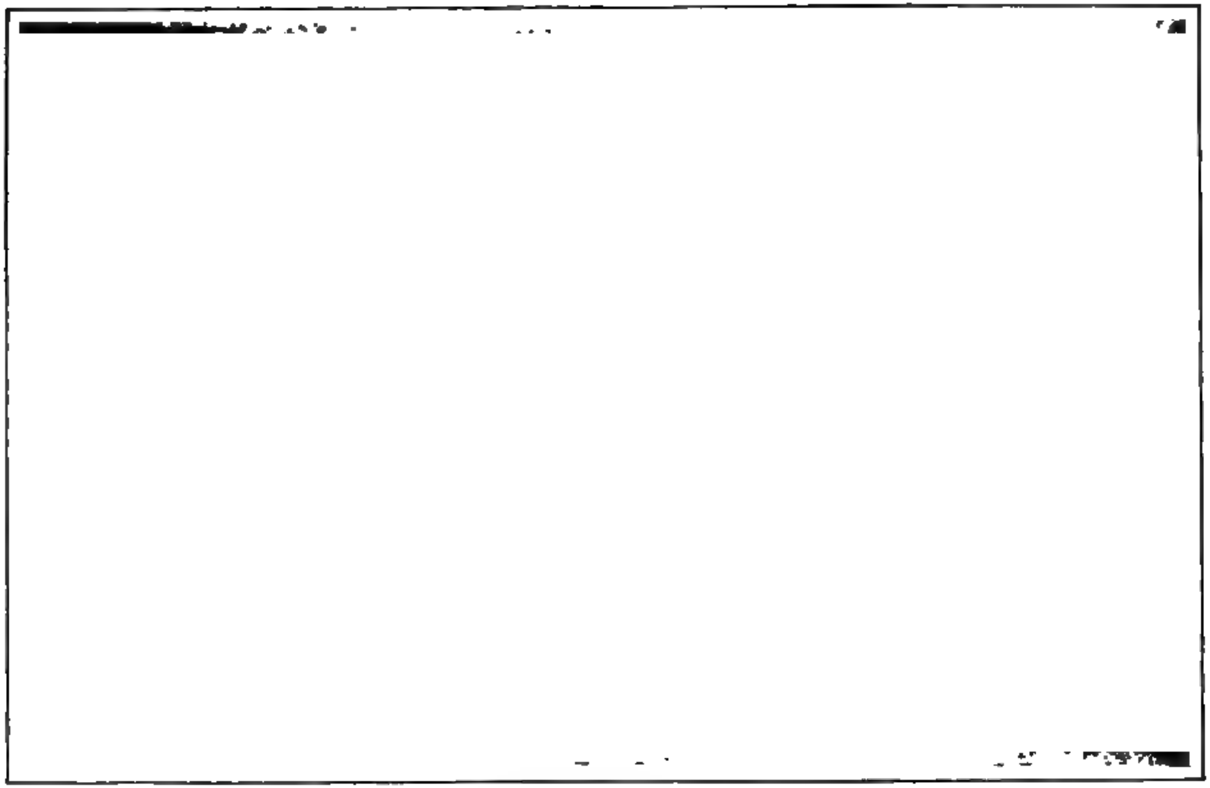
By being able to use this water for the boilers a great economy was effected, but in some of the P. and O. liners the boilers suffered rather badly, since an injurious chemical action was set up owing to the continuous return of the same water backwards and forwards from the condenser. Nowadays the problems connected with the condenser have been fully mastered, and the advantage of being able to use distilled water is obvious; for one of the surest and quickest methods

of bringing about ruin is to use sea-water for the boiler, over which it will lay a thick crust of salt.

The third illustration facing page 184 is interesting as representative of a type of coasting steamer introduced about the year 1855. She shows very well the simplest form of an iron ship propelled with a screw, and evinces sufficient resemblance to the dying sailing ship before the steamer had taken on a distinctive character of her own. In a word, here is the steamship not in her crudity, as in the case of the *Clermont*, but certainly in her elementary form without any of those extra decks and houses which were still to come, and which to-day give such distinct personality to the steamship. It will be seen that she is just a flush-decked vessel, with a central protection amidships for her engines and boilers. There is no forecastle, no poop, and in the development of type she stands at the beginning. She was built for the North Sea trade, and in bad weather must have been a singularly wet boat. She was only of 677 tons gross register, and the absence of any shelter would, when steaming to windward in a bad sea, cause her to be swept from end to end. Similarly, her stern being equally unprotected by either poop or quarter deck, she would be at the mercy of a bad following sea. It was not surprising that this elementary type soon gave way to those modifications that we shall see hereafter. In design of her body this present model illustrates again Scott Russell's system of obtaining a capacious ship combined with the qualities of slipping through the water with the minimum of resistance. This will be especially noticeable by regarding the long straight middle body. She was propelled by oscillating engines, and a two-bladed screw, having also sails on her three masts.

And so we come to that famous monstrosity and wonder of her decade the *Great Eastern*, some idea of whose appearance will be obtainable from a model of her, illustrated herewith. Here again will be found a repetition of a curious rig with the half-dozen masts, of which the second and third carried yards and square-sails, and the others the usual fore-and-aft sails set on the gaffs here seen. Although she carried one triangular headsail, yet this was a staysail, and it is significant that in this notable ship we find the disappearance of the bowsprit, a change that is so characteristic of the modern liner. Much more than either the *Great Western* or the *Great Britain* this epoch-making monster stands for something altogether distinctive in the evolution of the steamship. Frankly, in spite of her virtues, she was a creature born out of due time. Historically, she exhibits in no uncertain manner the extraordinary and almost incredible speed at which the development of the steamship had progressed in fifty years, during which period designers, ship-builders, and engineers had to feel their way in the most cautious manner. No ship was built with such a length as hers until the White Star *Oceanic* in 1899; no vessel ever had such a beam until the coming of the *Mauretania* and *Lusitania*, and even they only exceed the *Great Eastern's* extreme width by a mere five feet. But it is half a century since the latter was built, when all the experience that we possess now was not yet obtained.

Originally she had been named the *Leviathan*, and her beginning happened as follows: Already the fact had come to be appreciated that there was a superior advantage in a large steamer compared with a ship of smaller size when voyages of considerable distances were contemplated, and that, as already pointed out on a previous page, length of hull,



THE "GREAT EASTERN" (1858).

From the Model in the Victoria and Albert Museum.

other things being equal, makes for speed. In designing the *Great Eastern* with an extreme length of 692 feet she spanned over so large a number of wave-lengths that the possibility of pitching was very decidedly reduced. But even in smooth water length still means speed, and to take the case of a rowing "eight" and compare it with a single "sculler," we find that this law is well exemplified. Without pursuing so interesting a point beyond our limitations of subject, we might remark that quite recently an expert took the trouble to work out data obtained from the performances respectively of a Leander "eight" and a "sculler" as observed at a Henley Regatta. Although the displacement of the eight-oared craft works out at about 240 pounds per rowing man, or including the coxswain at about 217 pounds, whilst the sculler only displaces 208 lb., yet for all that the speed of the longer boat was found to be greater in the proportion as 9.75 knots are to 8.12 knots, and this, bear in mind, while the eight is carrying a ninth man who contributes nothing to the speed of the craft. We mention this as a simple example of that important fact of the superiority of length in ship-making, an importance that is now exhibited so clearly in the enormous lengths of the latest liners.

Brunel, who had already broken steamship records by his previous daring essays, suggested to the Eastern Navigation Company the building of such a ship as would be able to carry an unheard-of number of passengers, a very large amount of cargo, and at the same time be capable of steaming all the way to Australia without having to coal on the voyage. These virtues, together with her speed of fifteen knots, would, it was thought, enable her to attract such a large amount of business that she would handsomely repay her owners.

The contract was eventually given to Scott Russell's firm, who were entrusted with the building of the ship, together with the paddle-wheel engines. The screw engines were made by Messrs. James Watt and Co., so that three of the names most prominently connected with the history of the steamship were especially associated with the construction of this leviathan. Brunel was assisted in the designing by Scott Russell, and the latter's wave-line principle was followed. The building of the ship began on the 1st of May, 1854, and on the last day of January, 1858, she was sent into the water at Millwall. But this was not done without some difficulty. The first attempt to launch this enormous mass of 12,000 tons was unsuccessful. Her weight was resting on a couple of gigantic cradles which were to slide down an incline to the water; but they only moved a few feet and then stopped. Finally, three months after the first effort, she was slowly persuaded into the water, side-ways, by hydraulic machinery. Instead of running her on the route for which she had been built, where her exceptional abilities might have been utilised, she was put to compete with the steamships already running on the Atlantic, for which short voyage she was not specially suitable, and financially she spelt ruin all round. First, the attempts to launch her, and the ensuing delay cost £120,000 and the company, unable to bear the expense, was wound up. Then the new company which bought her for £160,000 were ill-advised to employ her in the American trade, for neither as a passenger ship nor as a cargo carrier could she be made to pay her way. Subsequently she was used in laying the Atlantic cable, and was handed over to the ship-breakers in 1888, who brought her career to an end during the next couple of years.

PADDLE ENGINES OF THE "GREAT EASTERN."

SCREW ENGINES OF THE "GREAT EASTERN."
From the Models in the Victoria and Albert Museum.

The *Great Eastern* was, in accordance with Brunel's idea, propelled by both paddle-wheels and a screw. An illustration is here given of a model of her paddle-engines, which were of the oscillating type. It will be borne in mind that the leading advantages of this type lay in the fact of their comparative lightness in weight, and their economy as regards space. If the reader will just glance at the illustration which faces page 138 of the *Great Eastern's* longitudinal section, he will be able to see what little room these engines actually needed. It will be noticed in her paddle-engines that each of two cylinders drove a crank, the cylinders being placed vertically but at an inclined angle. Each paddle-wheel could, if desired, be driven separately. The condensers were of the jet type, and there were two air-pumps, which were driven by a single crank in the middle of the paddle shaft. The paddle-wheels were tremendous, weighing ninety tons each, and measuring fifty-six feet in diameter. But the *Great Eastern* amply proved how unsuitable the paddle-wheel was for ocean work. Every time the big monster rolled in a bad sea a great strain was put on the machinery; these vast projections, too, offered not merely increased windage and accentuated the ship's general unwieldiness, but afforded a fine target for the Atlantic waves to smash against. Once the *Great Eastern*, during a gale in the year 1861, suffered pretty badly in this respect, when the paddle-wheels were destroyed. She was afterwards fitted with wheels five feet smaller in diameter, and of greater strength.

In the next illustration will be seen a model of her screw engines, whose position in the ship will be found on referring again to the longitudinal section. These were, it will be noticed, no longer of that early type which needed gearing, but worked directly, the cylinders being placed horizontally.

The number of cylinders was four, each of which had two piston-rods, and steam was supplied by half a dozen double-ended tubular boilers of the rectangular or "box" type. For the benefit of the non-technical reader we may explain that the object seen in the foreground of the picture, extending from the centre to the right-hand side, is what is commonly called the "link motion gear," which is employed for reversing the engines when it is required to send the ship astern. This controls the slide valves which allow the steam to enter the cylinders. The principle of the link motion is just this: two eccentrics are placed side by side on the shaft, but opposite to each other. Each of them is connected by a rod to one end of the "link," which is curved in shape. In this illustration it will be easily recognised at the right-hand side in the front. Now, as the link is moved up or down, so it controls the eccentric. If it is lowered, for instance, then one eccentric only is working the valve, but if the link is raised the other eccentric will control the valve, and so the latter will work in the opposite direction to which it did before. Thus, by using one eccentric, steam enters the cylinder at one end first, while if the other eccentric is employed steam will enter first at the other. Thus it becomes possible to make the engine turn in whichever direction is desired by regulating the end of the cylinder by which the steam shall first enter.

The *Great Eastern's* propeller had four blades, and an interesting arrangement was adopted so that when the ship was proceeding by means of her paddles, sails, or both, the screw propeller was kept revolving by means of two auxiliary engines in order that the speed of the ship through the water might not be diminished by the drag of the screw. Actual results showed that this ship could do her fifteen knots with

screw and paddles, but her average speed was one knot less. Under screw alone she could do nine; under paddle power alone she did seven and a quarter. It will thus be noticed that when using both paddles and screw she ought to have done better, and this failing is explained by asserting that the paddle-wheels and the screw caused a resistance too great for their respective engines.

The construction of this ship calls for more space than we can here devote thereto, but some of the important features may be enumerated. She was of great strength longitudinally, and from the keel to the water-line her hull was double. The longitudinal bulkheads extended to the topmost deck, and materially added to her strength, while the inner skin just mentioned not merely gave added strength, but was an extension of the double-bottom idea, and so increased her chances in case of collision. Furthermore, the space between the two skins was available for water ballast, so as to preserve the trim of the ship as she neared the end of her voyage, and her coal bunkers were becoming lightened. Transversely, also, the ship was divided by iron bulkheads into water-tight compartments in addition to the longitudinal ones. The iron plates out of which the ship's skin was made varied from a half to three-quarters of an inch thick. The *Great Eastern* was able to give the world a very convincing proof of the utility of the double bottom, for she had the bad luck to run on a rock, and although more than a hundred feet of her outer hull was afterwards found to be damaged, yet she was able to complete her voyage without the water getting through into her hull proper.

For steering so large a vessel as the *Great Eastern* the usual type of steering-wheel would clearly have entailed the

expenditure of very considerable physical effort; so, for the first time, was introduced in this ship a steam steering gear, an example that is nowadays followed by almost all steamers of any size, including even excursion boats. This arrangement necessitates the use of a miniature steam engine, the two cylinders working cranks, and the shaft causing the drum containing the steering chain to revolve. Any movement of the steering wheel admits steam, and as soon as the steersman ceases to turn his wheel so quickly does the little engine cease to work.

We have no desire to try the patience of the reader by presenting a mass of statistics, but those who delight in comparisons may be interested to learn how the *Great Eastern* would appear if put alongside the *Mauretania.* The latter displaces 40,000 tons, the *Great Eastern* displaced 32,000. The big Cunarder is 790 feet long, between perpendiculars, while the *Great Eastern* was 680 feet. The latter possessed a combined horse-power—paddle and screw engines—of 11,600, while the Cunarder has 70,000. And so we could continue. But now that we have seen to what unheard-of limits the steamship had shown herself capable of reaching by the end of the sixth decade in the nineteenth century—how she had, step by step, grown from moderation to exaggeration—let us now examine her progress during the next twenty years, in which she passed through her transition period.

CHAPTER V

THE LINER IN HER TRANSITION STATE

The period which follows after about the year 1862 is notable as witnessing not only the gradual universal adoption of the screw in steamships, but the more general appreciation of iron as the material from which to construct a vessel's hull. After the prejudices which already we have seen arising at different stages of the steamship's history, it was scarcely to be wondered at that iron should come in for its full share of virulent criticism and opposition. The obvious remark made on all sides was that to expect iron to float was to suppose that man could act exactly contrary to the laws of Nature, and this notwithstanding that already, besides barges, a few ships thus built had somehow not only managed to keep afloat, but to traverse channels and oceans in perfect safety, carrying such heavy weights as their own machinery, to say nothing of their cargoes and human freights. But slowly the public prejudice began to wane. Already the Cunard Company had given way to iron in 1856, and in 1860 the Admiralty were at last convinced that the new method was just and sound. Within the limited scope at our command we have not space here to enter into the elaborate discussion of matters which have to be taken for granted before the building of the steamship begins. But the plain answer to the natural inquiry, as to how and why a vessel made out of iron does not immediately sink to the bottom as soon as ever she is launched,

is this: whereas iron in itself is far heavier than water, yet the iron ship has not the same specific gravity as the iron from which it is made. Therefore, the ship of this material will be supported by the water in which it is placed.

In actual displacement, an iron ship is proportionately lighter than a ship built of wood, and by "displacement" is meant the amount of water which a vessel displaces through being allowed to float. Of course, the quantity of water which a ship displaces (or pushes to one side) depends entirely on the weight of the vessel, and is exactly equal to the weight of the ship. Thus, suppose we were to fill a dock with water up to the level of the quay and then lower down into it by means of gigantic cranes a *Mauretania* or *Lusitania*, the water would, of course, flow over on to the quays. Now the amount of water thus driven out would be the exact equivalent of the liner's displacement. When we say, for instance, that the displacement of the *Mauretania* is 40,000 tons, when loaded, we mean that her total weight when loaded is this number of tons, and her hull when afloat puts on one side (or "displaces") just that amount of water.

Now, as compared with wooden ships, the use of iron meant a saving in displacement of about one-third, taking the wooden and the iron ships to be of the same dimensions. From this followed the fact that the iron ship could carry a greater amount of cargo with consequent greater profit to her owners. And, as I have already indicated in another chapter, before it was possible to build ships of great length iron had to be introduced to enable them to endure such longitudinal strains. Again, a wooden ship must have her skin and ribs made of a thickness far greater than an iron ship, for the clear reason that one inch of iron is much stronger

than one inch of wood; in other words, to obtain a given strength the iron will take up less room in the ship. Thus in an iron steamer there will be more space available for cargo than in a wooden ship of the same design. We could go on enumerating the advantages of iron, and quote instances of iron ships, whose cargo had got on fire, arriving safely in port and coming into dock where the assistance of the local fire-brigade had enabled the vessel's own pumps to get the conflagration under. It is only as recently as December of 1909 that the *Celtic*, the well-known White Star liner, during a voyage between New York and Liverpool, had the misfortune to get on fire while at sea. By means of tarpaulins and injections of steam it was possible to control the burning until the Mersey was reached, when it was intended to flood her holds. Had she been a wooden ship instead of steel, or even iron, the *Celtic* would undoubtedly have ended her days in the Atlantic.

The first Atlantic company to build all its steamers of iron was the Inman Line, which had been founded in 1850, and until 1892 was one of the foremost competitors for the coveted "blue ribbon" of the Atlantic. Their first ships had been the *City of Glasgow* and the *City of Manchester*, and these, inasmuch as they were built of iron, and were propelled by a screw at a time when prejudice had not yet died down, were entirely different from the prevailing type of steamer; and this, it should be remembered, at a period six years before the Cunard had built their iron *Persia*. This *City of Glasgow* was built by a Glasgow firm of shipbuilders, and Mr. Inman had sufficient confidence in her to purchase her and form a company. Barque-rigged, with a single funnel, she was of only 1,610 tons and 350 horse-power. Under the command

of Captain B. E. Matthews, who had been on the famous *Great Western,* she had already crossed from Glasgow to New York and back in 1850, and on December 11th of that year began her regular sailings between England and America. The *City of Glasgow*—all the ships of this line were named after cities—was fitted up in a manner which at that time called forth the greatest admiration. "One room," wrote a correspondent in the *Glasgow Courier,* about that date, "is being fitted up as an apothecary's shop, from which the surgeon will dispense his medicines." She was provided with five water-tight bulkheads, and had a propeller whose diameter was 18 feet, with an 18 feet pitch. It was in connection with the Inman ships that the custom was inaugurated of carrying steerage passengers on the best Atlantic liners, although hitherto they had been taken across solely on board sailing ships.

The *City of Glasgow* and the *City of Manchester* began to quicken the pace, and at once ensued a contest between the paddle-steamers and those propelled by screws. In 1857 this enterprising company instituted the custom of calling at Queenstown on the way to America, and began running their steamers to New York in place of Philadelphia. Their success was so great that these ships were followed by the *City of Philadelphia,* and, in 1866, by the *City of Paris,* of which a beautiful little model is here illustrated. This was the first of their steamships of that name, and is not to be confused with another ship built in 1888. It will be seen that the liner before us was ship-rigged and had a single screw. She measured 346 feet long, 40 feet wide, and 26 feet deep, her tonnage being 2,651. She was driven by horizontal trunk engines, with steam at 30 lb. pressure, consuming 105 tons of coal per day, and giving her a speed of 13½ knots. Her name was

THE "CITY OF PARIS" (1866).

From the Model in the Victoria and Albert Museum.

THE "RUSSIA" (1867).

From a Painting. By permission of the Cunard Steamship Co.

afterwards changed to the *Tonquin,* and the superstitious will find interest in the fact that she subsequently foundered at sea in the year 1885. In the *City of Paris* the reader will be able to remark some of the last traces of the old sailing ship, which were destined presently to be altered considerably. The long, narrow wooden deckhouse going down almost the length of the ship, and leaving but little room for the passengers to promenade; the high, stout bulwarks, which rise almost to the top of the deckhouse, were among the last links which connected the steamship with the sailing ship. We must not forget that about the time when the *City of Paris* was built, the great clipper sailing ships were enjoying their prime, and no one will deny that their influence is very clearly marked in the model before us. As an interesting lesson in comparisons, showing how the tendency since the 'sixties has been to raise the decks of the steamships higher and higher, the reader is invited to compare this illustration with that of the *Majestic,* facing page 162, and also that of the *Kaiser Wilhelm II.,* facing page 180. In the sailing ship the deckhouse had to be small, for the reason that the deck space was required for the crew to work the sails; in the steamer this space was encroached upon, so that the deckhouse was elongated, and extended from the break of the anchor deck to the hood at the stern.

The *City of Paris's* great rival came with the launching of the Cunard Company's steamship *Russia,* which is here illustrated, and began running across the Atlantic in 1867. But though the latter's quickest passage from New York to Queenstown was eight days twenty-four minutes, the *City of Paris,* in 1867, crossed in eight days four hours, which at the time had broken the record, though the *City of Brussels* reduced it still further to under eight days. The *Russia* was another

Clyde-built boat, and measured 358 feet long, 43 feet broad, and nearly 28 feet deep, having a gross tonnage of 2,960, and an indicated horse-power of 2,800. Her average hourly speed was 13 knots on a coal consumption of 90 tons per day. She was, of course, built of iron and had a single screw—two characteristics which practically all the crack Atlantic liners possessed from about 1862 until the end of 1888, if we except the Cunard *Servia*, which was launched in 1881, although the Allan liner *Buenos Ayrean* had been the first steel ship on the Atlantic.

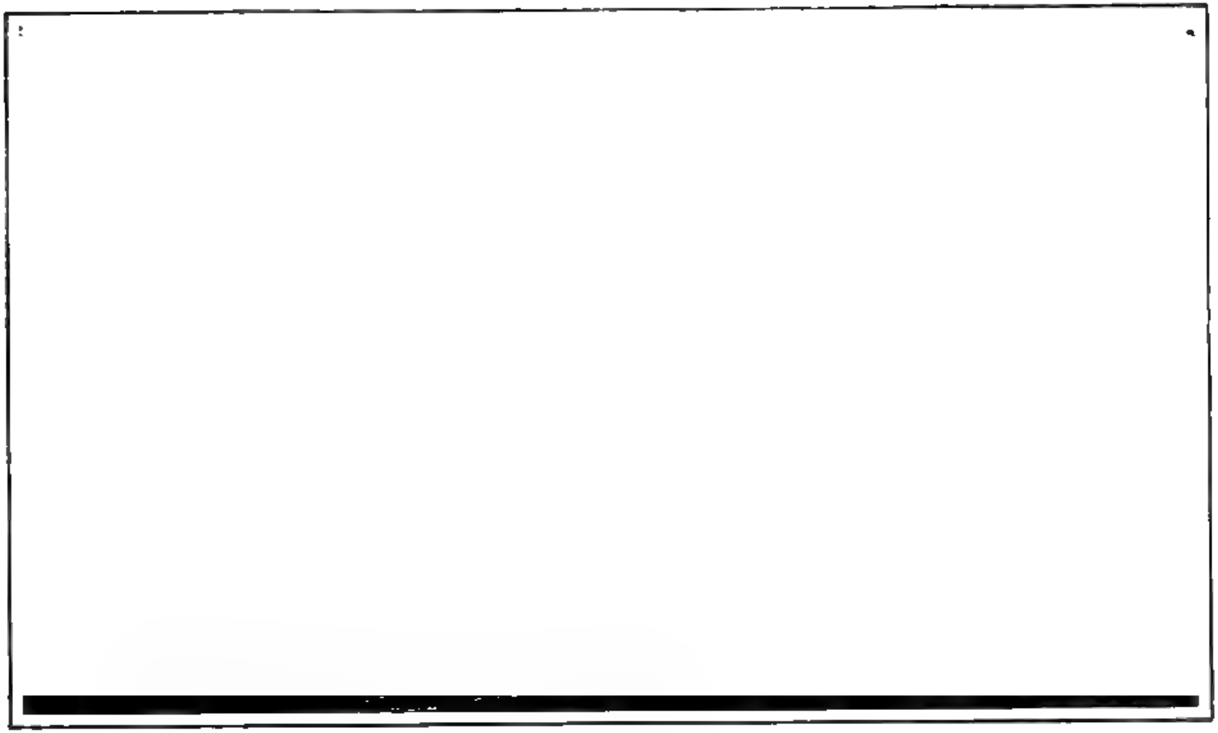
During this period the liner was steadily adapting herself, her design, her engines, and her build, to meet the increase of experience gained at sea, and the increase of knowledge which shipbuilders and engineers were accumulating was in readiness for the continuity of advance. In 1881, after a period of much usefulness and great popularity among passengers, the *Russia* was sold to the Red Star Line, who lengthened her, changed her direct-acting engines to compound engines, and named her the *Waesland*. But the *Russia* was not the first screw-ship possessed by the Cunard Company. Already I have mentioned that though this line had introduced the screw-steamer into their fleet, it had not met with the reception it had expected, and for a time a return had been made to the paddle-wheel. It was the *China*, which had begun running in 1862 to New York, that helped to convince those who were prejudiced against the newer form of propulsion. She was 326 feet long, and was driven by a type of surface-condensing engine geared down to the propeller shaft by means of tooth-gearing after the manner already described, her engines being of the oscillating kind.

But we approach now another of those important crises

in the history of the steamship when her future, for some years to come, became so definitely moulded. On other pages I have already alluded to the boilers in use on the big steamers, and to the important adoption of the compound engines using the expansive force of steam to do additional work after it has entered one cylinder. The increase of steam-pressure necessitated the adoption of a different type of boiler, with a cylindrical shell and flues. Thus the type which is known as the "Scotch" boiler was introduced about the year 1870, and is still in use even on the *Mauretania*. It was not until this type was adopted that the compound system began to make progress. At the same time it is only fair to state that the latter method had been introduced by the Pacific Steam Navigation Company as far back as 1856, and by the National Line in the early 'sixties. But it is when we come to the pioneer steamship of the White Star Line that we see the real influence which was at work to make the final cleavage between the old-fashioned steamship and the new type of liner. That flag which is now so familiar to all who travel across the Atlantic used to fly at the masthead of a fleet of sailing clippers. In 1867 the managing owner of the White Star Line retired; Mr. T. H. Ismay took over the control and began by introducing iron for the clippers instead of wood. Two years later and a fleet of steamships, especially constructed for the American passenger trade, was ordered to be built. The order was given to that famous Belfast firm, Messrs. Harland and Wolff, who have built the White Star steamships ever since. In August of 1870 was launched the first *Oceanic*, which made the old-fashioned rub their eyes in surprise and shake their heads in distrust. For the *Oceanic* simply threw convention to the winds and set going an entirely new order of things

in the steamship world. From her have followed most of the modern steamship improvements up to the coming of the turbine. Some idea of her appearance may be gathered from the illustration facing this page, but in the fewest words we will now endeavour to indicate some of her especial characteristics.

When she came into the Mersey that memorable day in February of 1871 her immense length in comparison with her beam was instantly noticeable. I have already explained the value of length in ocean travel, but here was a ship with a beam exactly one-tenth of her 420 feet length. Sir Edward Harland knew what he was about when designing so novel a craft, and in spite of the general comments that the *Oceanic* would prove a bad sea-boat, and unfit to face the terrors of an Atlantic winter's gale, she showed that science in shipbuilding is of more avail than the blind following of an existing convention. Nor did she encumber herself with the usual heavy, high bulwarks that we noticed in the *City of Paris*, but, instead, she substituted iron railings, and for a perfectly sound reason. The old method gave to a ship a false security, for it could not altogether prevent a sea from coming on board, and when the latter had come over the ship the bulwarks tended to keep it there, whereas the *Oceanic's* railings allowed the sea to flow off immediately and freely, as she shook herself and rose to the next wave. The long, narrow wooden deck-house that we also noticed on the *City of Paris* was also discarded, but another deck of iron was added. With her, too, disappeared most of the objections to the propeller—at any rate, in the higher-priced accommodation, since the saloon passengers for the first time were placed not at the stern of the ship (where the vibration and jarring of the propeller were most felt), but amidships and forward of the machinery. The



THE "OCEANIC" (1870).

From the Painting by W. L. Wyllie, R.A. By permission of Messrs. Ismay, Imrie & Co.

saloon extended the entire width of the ship, whilst the numerous state-rooms were forward and abaft of the saloon. Furthermore, to an extent that had never been known on an Atlantic liner, the use of glass side-lights was employed, and these were made much larger than was customary, so that the interior of the ship was rendered much lighter, as it was also made more airy.

The *Oceanic* also introduced an improved type of water-tight doors. The old-fashioned candle-lamps which lit the rooms were replaced by oil-lamps, and instead of the old-fashioned form for seating, the passengers had the comfort of revolving arm-chairs, which have since become such features of ocean travel. On deck, her forward and stern ends were fitted with turtle decks, so that a wave sweeping over this dome-like shape could swish across it without doing the damage it could have effected on the first *City of Paris*, for instance. The importance of this in a following sea of any size is obvious, and we must remember that whereas to-day the stern of a modern liner towers high above the waves, and can usually defy them, yet in those days the *Oceanic* and her contemporaries were still of modest altitude. From the illustration before us some conception of the bow turtle deck, painted white, may be gathered, but a much better idea may be seen of a similar arrangement at the stern of the *Britannic* (facing page 154). The addition of that extra deck of iron in the *Oceanic* shows the commencement of the many-decked modern liner, to which attention was drawn in the German liner and her successors, so that in the *Mauretania*, as we look down on her decks, she seems to be built up over every possible inch of space that is permissible.

But the *Oceanic* was something more than a comfortable

boat and an ingenious example of the naval architect's originality; she was also a "flyer." With her four-cylinder compound engines she was able to reel off her 14½ knots on an average. There were two high-pressure cylinders and two of low-pressure, the high-pressure cylinder being above the low-pressure and driving the same crank. Her indicated horse-power was 3,000, and her tonnage came out at 3,808 gross. She even attained to 14¾ knots, and showed herself to be the fastest liner afloat, faster even than the Inman liner *City of Brussels*. It is a proof of the excellence of her design and the perfection of her build that on her sixty-second voyage in October, 1889, after she had been transferred to the Pacific service running between San Francisco and Yokohama, she made the quickest passage on record across the Pacific.

The owners of the *Oceanic* followed up their success by the *Britannic* and the *Germanic* in 1874. A photograph of the former is here reproduced as she appeared when leaving Southampton during the Boer War for South Africa, acting as a transport, with British troops aboard. From this picture it will be noticed that she is purely a steamship, but when launched she was rigged as a four-masted barque with yards and sails, but, following the fashion of the *Oceanic*, the bowsprit had been discarded. At one time the *Britannic* was given a curious arrangement by which she could lower her propeller so that it was almost level with the keel, and being placed thus low it was hoped that all tendency to race when the vessel pitched would be eradicated. To this end a hollow recess was made in the hull at the stern so that the shaft could be made to work up or down as desired. But the results were disappointing, so that after giving the method several months' trial it was discarded. Both the *Britannic* and the *Germanic*

THE "BRITANNIC" (1874).

As she appeared as a transport during the South African War.

From a Photograph by F. G. O. Stuart, Southampton.

THE "SERVIA" (1881).

From a Painting. By permission of the Cunard Steamship Co.

were larger craft than the *Oceanic*, and had a tonnage of just over 5,000 tons, and a length of 468 feet, with 45 feet beam. They also were fitted with compound engines, which gave 5,000 indicated horse-power, and a pressure of 75 lbs. to the square inch. The *Britannic* broke the record again by her speed of 16 knots, but the year after her launch the Inman Line, with the *City of Berlin*, also developed 16 knots, and wrested the record from the White Star boats by crossing the Atlantic in seven days fourteen hours. She was a much larger ship than those other two, had a gross tonnage of 5,491, and was 520 feet over all. This ship is interesting as having been the first Atlantic liner to be fitted with electric light, which was installed in 1879. The White Star Line, however, had endeavoured in 1872 to instal in their *Adriatic* a system of lighting the ship by gas generated from oil. But the rolling of the ship and other causes led to so much leakage that it was discarded.

In the year 1879 the Atlantic competition was further accelerated by the advent of the *Arizona*, which belonged to the Guion Line. This company had been formed in 1866, and was originally known as Williams and Guion. In 1879 the *Arizona* further reduced the Atlantic passage by eight hours, but in the same year, whilst bound eastwards, she had the misfortune to run at full speed into a great iceberg, and her bows were altogether crumpled up; she would have foundered, but her water-tight bulkhead happily kept her afloat so that the ship was able to reach St. John's, Newfoundland, her nearest port. It was such incidents as this which caused the adoption of efficient water-tight compartments on most steamships of any size, and the influence of the British Admiralty on our national shipping was in the late 'seventies

and the early 'eighties decidedly powerful. By their instructions every steamship on their list available for transport duties was to be divided up in such a manner that if any one of her compartments should be opened to the sea in calm water this loss of buoyancy would not imperil the ship's safety. As a result the shipbuilders took the hint, and greater attention was paid to so important a point.

The *Oregon*, another of the Guion Line's famous steamships, was purchased by the Cunard Company, and showed her marvellous turn of speed by making the run from Queenstown to New York in six days, nine hours, fifty-one minutes. She distinguished herself by keeping up what was then the unheard-of average passage of six days fourteen hours. But, like the *Arizona*, this *Oregon* was born unlucky. Off the North American coast she was run into and sunk by a sailing ship, though the passengers and mails were happily saved. The *Oregon* had a tonnage of 7,375, and was driven by direct-acting inverted engines which developed the remarkable sum of 18,500 horse-power, and produced the equally wonderful speed of 18 knots per hour, thus earning for her the name of the "Greyhound of the Atlantic."

We wish to call the reader's attention now to the *Servia*, of which an interesting picture is reproduced opposite page 154. In her was embodied the result of another scientific discovery which has revolutionised the construction of the deep-sea ship, whether propelled by steam or sails. As iron had superseded wood, so now steel was to take the place of iron as the material of which to build the hull. So thoroughly, indeed, has this practice spread that during the year 1909, with the exception of a few small wooden vessels whose aggregate tonnage does not much exceed a thousand, the entire amount of new

British shipping in that year was constructed of steel, and iron was not used at all for the hull. Such a fact is highly significant of the value of the newer material. Although as far back as 1878 the French had used this in constructing parts of their warships, it was not until four years later that the British mercantile marine began to be interested in it. But at length the Cunard Company were convinced of its superior virtues over iron, and ordered the *Servia* to be built of this material. When she made her appearance in 1881, she was the largest and most powerful ship, excepting the *Great Eastern*, that had ever been launched; her measurements were 515 feet, breadth 52 feet, depth 37 feet, with 7,392 gross tonnage. She lowered the Atlantic voyage once more to seven days, one hour, thirty-eight minutes, her speed being 17 knots, though it was not until 1884 that she really showed her full abilities. We may sum up the advantages which were now recognised in mild steel as consisting of, firstly, a saving of 25 per cent. in weight, just as we saw that iron exercised a similar superiority over wood. "Mild" steel is very ductile and can easily be fashioned into the required shape suitable for a steamship without risk of cracking. Iron is comparatively brittle, and steel is more uniform in quality. The latter will also endure a greater strain on its elasticity, and this had already been appreciated by the Royal Navy years before commercial shipbuilders realised its full value. Although the first cost of a steel-built ship was greater than one constructed of iron, yet that extra cost was found to be over-balanced by other considerations. Just as iron was stronger than wood, so steel was proved to be stronger than iron: consequently, the weight of the ship was diminished, which meant that the ship could carry a greater amount of

fuel or cargo, or allowed of her being fitted with more powerful, though more weighty, engines. Steel is now very much cheaper than wrought iron, and is used not merely for the plates of the hull, but in almost every portion of the ship's construction. Even in sailing ships the yards, masts, and rigging are to a large extent now made of this material.

The same builders who had been responsible for the *Oregon* were commissioned to build two of the most historic Cunarders, whose names are almost as familiar as the Atlantic over which they voyaged for so many years with a regularity and reliability that would be hard to beat. In 1884 the first of this famous couple, the *Umbria*, was delivered, followed early the next year by the *Etruria*. An illustration of the former, as she appeared when originally rigged as a barque, will be found facing this page. Both ships were identical in their main features, and are interesting in many ways. Their masts were of steel, as well as their hulls. At the stern we can see the idea of the turtle deck, as inherited from the *Oceanic*, slightly modified so that the upper part has become available for a short promenade deck for second-class passengers, and the graceful overhang at the stern also is indicative of the rapid advance since the clumsy after-end of the steamship gave her a far less yacht-like appearance. There is also a promenade deck extending for nearly 800 feet amidships for the use of the first-class passengers, on which a large teak deckhouse encloses the entrances to the saloon, ladies' saloon, captain's room, and chart room. Above this house comes the officers' look-out bridge and house for the steersman, and over this, again, is the flying bridge. Forward there will be seen the large top-gallant forecastle, which extended for over 100 feet aft from the stem. The engines were, of course, compound, with

THE "UMBRIA" (1884).

From a Painting. By permission of the Cunard Steamship Co.

THE "ORIENT" (1879).

From a Painting. By permission of Messrs. Anderson, Anderson & Co.

one high-pressure cylinder and two of low-pressure. These vessels were built to the highest class and to be available for Government service as armed cruisers in the event of war. Their average speed was found to be 18½ knots, although the *Umbria* reached over 20 knots during her six-hours' trial on the Clyde. These two ships between them broke up all standing Atlantic records, for in August, 1885, the *Etruria* crossed from Queenstown to New York in six days, six hours, thirty-six minutes, although in 1892 the *Umbria* did better still by crossing the Atlantic at an average rate of over 19½ knots. Until the coming of the *Campania* and the *Lucania*, the Cunard possessed in these the two fastest ships of their fleet. But it is certain the company never owned two more satisfactory steamships, for they have confessed that "no ships ever gave their owners less uneasiness than these two, and none have done such an extraordinary quantity of good work. They are monuments, that cannot lie, to the skill of the design and the faithfulness of the labour that went to their accomplishment."

As they got older, they actually became faster instead of slower, and the *Etruria* made her fastest westward passage in five days, twenty hours, fifty-five minutes, with a highest day's run of 509 knots. She even maintained an average of 20 knots bound eastward. At the end of 1909 she was sold by the Cunard Company, and a like fate befell her sister, the *Umbria*, which was sold to the Forth Shipbreaking Company in April, 1910, for the sum, it is said, of £20,000. But the *Umbria*, right to the end, continued to break records, even when she had been long since outrun in matters of speed. For instance, in the year 1898, two days before Christmas, whilst bound west across the Atlantic, it was discovered that

a serious fracture had occurred in the propeller shaft. The engines were accordingly stopped, and after a time the German steamship *Bohemia* came in sight and took her in tow, but a heavy gale sprang up and the tow-rope parted. The *Umbria* lost sight of her friend and drifted about the Atlantic for three days and nights, but during this time Chief-Engineer Tomlinson pluckily succeeded in repairing the shaft, and the *Umbria*, with her engines going half-speed, made New York on the last day of the old year, to the great relief of those ashore who had given her up for lost. Another record of a totally different nature was made by her only a few weeks before she was sold out of the Cunard Line. She reached Liverpool just before midnight on Thursday, February 10th, 1910, and in spite of having only just completed her round trip of the double Atlantic journey, she was got ready at once to sail eastward again on the Saturday, February 12th. We can gain some idea of the magnitude of the task when we realise that in that remarkably brief time she had not only to be overhauled, but to have her stores taken on board, to be supplied with 3,000 tons of coal and 450,000 gallons of water, to say nothing of the many tons of cargo of all kinds. Some of the officers had barely time to make a hurried call to see their wives before rushing back on board to superintend this exceptionally fast "turn-round." The measurements of these two ships were 501 feet long, 57 feet broad, 38 feet deep, with a gross tonnage of 7,718 tons; their builders were Messrs. John Elder and Company, of Glasgow.

Before we pass on in the next chapter to witness the coming of the twin-screw ship, and the disappearance of sails as the auxiliaries of the steamship, we must glance at the progress which was going on during the 'seventies and 'eighties in

the steamships employed running, not across the Atlantic, but to the East. Already we have seen something of the origin of the Peninsular and Oriental Line, and the difficulties which it had to contend with in its early career. Now, in 1877, another steamship service to the East was started by the Orient Line, which began by chartering from the Pacific Steam Navigation Company a suitable vessel which should run from London to Sydney via the Cape of Good Hope. This was the *Lusitania*—a very different ship, of course, from the modern Cunarder of the same name—but in her own time this *Lusitania* was also famous. For many years, until, indeed, as recently as 1905, the Orient and Pacific Lines worked together to maintain a service between England and Australia. At first the sailings were only monthly, but from 1880 they were fortnightly. Since 1905 the Pacific Company has withdrawn from this trade.

The pioneer of the Orient Line's own ships—apart from chartered vessels—was the steamer *Orient*, of which an illustration is given opposite to page 158. She was built of iron, in 1879, by the same firm who turned out the *Etruria* and *Umbria*. Her measurements are 460 feet long, 46½ feet wide, 36 feet 8 inches deep, with a tonnage of 5,386, and 5,400 horse-power. She was given four decks, of which two were entirely of iron, and sufficient bunker space was provided to carry enough coals to enable her to steam all the way to Australia round the Cape without having to coal *en route*. She was also provided with a double bottom, which could be filled with water as ballast, if desired. She was driven by inverted vertical engines having the compound principle—one high-pressure cylinder and two of low-pressure—and had a four-bladed propeller. Amidships, it will be noted, is a white erection, which rises

up from the ship's side and becomes the bridge-deck, extending right across the ship and some distance both fore and aft. The origin of this development in the steamship is as follows: Originally, in some of the early ocean-going steamships, the openings on deck from the engine and boiler compartments were merely protected by means of glazed skylights and coamings, forming a hatch. Perhaps it was not a very seaworthy kind of arrangement, but it is essential for plenty of air to get down below, unhindered, for the proper burning of the furnaces, to say nothing of a supply for the engineering section of the crew. However, during the month of January, 1866, the steamship *London*, after encountering a heavy gale in the Bay of Biscay, endeavoured to make for Plymouth, but during the night a bad sea broke over her, destroyed her engine-room skylight, extinguished the furnaces, and eventually the ship foundered. From this incident was learnt the advisability of protecting this opening with something more substantial. Its first form was, therefore, to raise the sides of the hatchways from the ship by means of an iron casing so as to be about eight feet above the deck and about level with the captain's bridge. From this it was a perfectly easy transition from the bridge to the bridge-deck, extending it sufficiently to protect the opening adequately. The same idea in a more elementary form will be seen in the tug *Blackcock* illustrated in Chapter IX.

The *Austral* shows another early steamship of the Orient Line. Constructed by the same builders as the *Orient* and *Umbria*, she was launched in 1881, and it is a sign of those later times that the yards have now disappeared, though she was schooner-rigged and could set 28,000 square feet of canvas on her four masts. Her gross registered tonnage worked out at

THE "AUSTRAL" (1881).

From a Photograph. By permission of Messrs. Anderson, Anderson & Co.

THE "VICTORIA" (1887).

From the Painting by Frank Murray in the possession of the Peninsular & Oriental Steam Navigation Co.

THE "MAJESTIC" (1889).

From a Photograph. By permission of Messrs. Ismay, Imrie & Co.

5,524. Built of mild steel with a double bottom, the latter being subdivided into nineteen water-tight compartments with thirteen water-tight bulkheads in her hull, the *Austral* was specially constructed to act as a cruiser, and to carry guns in case of war. The year after she was launched the *Austral* was lying in Sydney Harbour with her port-holes left open, when, owing to a heavy list, caused through unequal coaling, the water poured in, and she sank in fifty feet of water, but was refloated again several months after.

The four-masted steamship shown opposite page 162 is the *Victoria*, one of the P. and O. boats of this period. Launched in 1887, the *Victoria* belongs to the company's "Jubilee" class, and is now one of the oldest boats in this line's employ. Both at the bow and stern there will be seen a modification of the turtle deck. A sister ship was launched under the name of the *Britannia*. Their tonnage is, in the case of the *Victoria*, 6,522, but the *Britannia* comes out at three tons more, the length being slightly over 465 feet, with a beam of 52 feet, and a depth of over 26 feet.

We have thus seen the liner in a condition of change, and it is only from the close of the eighth decade of the nineteenth century that she begins to take on a form more in accordance with a steamship able to pursue her way totally independent of auxiliary sails. The experience which we recorded as having happened to the *Umbria* clearly marked the way for the coming of the twin-screw ship. It was patent to anyone that by this means an efficient safeguard would be obtained in the event of a fractured shaft befalling the ship. If it was likely that one should come to grief, it was highly improbable that the other would not be available for getting the ship into port, and so enabling the owning steamship line not merely to

preserve their reputation for carrying passengers, mails and cargo with safety, but to avoid the very costly possibilities of having to pay salvage claims to the rescuing ship that should happen to fall in with the injured liner and to tow her home. As soon as the twin-screw became established there was virtually little use for the sails, and so it was not much longer before they disappeared altogether from the crack liner.

CHAPTER VI

THE COMING OF THE TWIN-SCREW STEAMSHIP

During the 'eighties the competition for the Atlantic "blue ribbon" had become very keen indeed, until the *Umbria* and *Etruria* began to shatter existing records and to show their undoubted superiority. But their turn to be eclipsed was not long in coming, and the Inman Line were determined to make a bold bid for supremacy once again. A year or two before the launch of the *Umbria* they had made a spirited effort with the *City of Rome*, a large vessel with a displacement of over 11,000 tons. But she did not prove successful.

The line became the Inman and International Company, and set forth to build a couple of large, powerful steamships which would be in advance of the *City of Rome* in speed, though not quite so large. Already there had been small twin-screw ships, but the *City of New York* and the *City of Paris* were to be driven by twin-screws of a size and power which had not yet been produced. It was fitting that the Inman Line which had introduced the successful screw liner to the Atlantic should also be the pioneers of the very big steamships fitted with twin-screws. These two vessels were taken over in 1898, when the Inman Line became reorganised, and passed from the British flag to sail under the eagle of the American Line. Nowadays they sail from Southampton under the names of the *New York* and the *Philadelphia* respectively. The illustration facing page 166 shows the *City of Paris* (afterwards called

the *Paris*, and only later still the *Philadelphia*) getting under way from New York. Her graceful bow, with its bowsprit and figure-head, is reminiscent of the old clipper sailing ships. The high dome of the first cabin dining-saloon will be seen rising in the space between the fore-mast and the bridge, and the promenade deck runs practically the whole length of the ship from the bows to the stern.

The hulls of these steamships are built of mild steel, and in addition to possessing a double bottom throughout their entire length in which a considerable amount of water ballast can be carried, they are divided into fifteen water-tight compartments. The bulkheads of the latter come right up to a height of 18 feet above the water-line, so that in case of collision the ship could still keep afloat even if three compartments were open to the sea.

Their two engine rooms are separated from each other by means of a longitudinal bulkhead, and they are driven by two separate sets of triple-expansion engines. We have already seen that triple-expansion is just the principle of the compound engine carried one stage farther, and if the desire for attaining the high speed contemplated were to be gratified it was inevitable that this method should have been adopted. With the exception of a very few quadruple-expansion engined ships, such as the Cunard *Ivernia*, the White Star *Baltic*, and the German *Kaiser Wilhelm II.*, most modern liners which have not been fitted with turbines are of the triple-expansion type. It may not be out of place, therefore, very briefly to explain the working of this.

The steam, then, enters the cylinder above the piston-rod by means of a valve, but when it has half-filled the cylinder and the stroke is also half completed, the supply of steam

THE "CITY OF PARIS" (NOW THE "PHILADELPHIA") (1893).

From a Photograph. By permission of the American Line.

THE "OPHIR" (1891).

From a Photograph. By permission of Messrs. Anderson, Anderson & Co

is cut off. But the piston-rod does not for that reason come to a standstill: owing to the expansive force of the steam the rest of the stroke is completed when the steam has occupied twice the space it did at the time it was cut off—that is, when the half-stroke had been made. Having, therefore, now completed its work in this cylinder, instead of being allowed to escape, the steam is conducted to a much larger cylinder than the first, for the steam still retains much of its expansive force. In this second cylinder, the same thing occurs again, but when it is admitted to a third, it has already lost much of its pressure. It does its work, and having come through the third cylinder has thus undergone "triple expansion." Now that it has completed the stroke it passes into the surface condenser already referred to, where it is suddenly chilled and converted into water again, and the vacuum thus formed tends to pull the piston back. In the olden days, as we have seen, the vacuum was made by means of the jet condenser, but now it is done by what is known as the "surface" condenser. It is by means of the latter that the fresh water is able to be used again and again. Otherwise, a steamship could only carry enough fresh water for a few days' voyage, salt water being not used for the boilers, but merely for circulating through the pipes of the condenser to keep them cool. As the steam comes out from the lower pressure it impinges on the sea-water cooled tubes and so falls to the bottom of the condenser as water. It is then pumped into a tank by means of the air-pump, and from the tank it is pumped back again to the boilers by a feed pump, passing on its way through a filter in order that any oil which may have been gathered in the cylinder may be extracted. It now passes through feed-heaters, where it is heated by exhaust steam from the auxiliary

machinery, and so when the condensed water again enters the boiler it is almost at boiling point.

The advantage of this triple-expansion was found to give greater speed with less expenditure of horse-power. At first the *City of Paris* was not as fast as she ought to have been, but after the A-shaped brackets, which supported the two shafts, were removed and, instead, the hull at the stern was, so to speak, bulged out to contain the shafts, her speed was found to be 19 knots with an employment of 2,000 horse-power less than she had needed before this alteration.

The *City of Paris* had made her appearance in 1888, but in the following year it was the White Star Line's turn to come to the front again. From 1878 till 1884 their fleet had been the fastest on the Atlantic; and now again they were ready to enter the lists. Sir Edward Harland was once more entrusted with the task of designing the new ships, and those two beautiful creatures the *Teutonic* and *Majestic* were launched, the former in January and the latter in June of 1889. The *Majestic* is illustrated opposite page 162, but this view shows her as she was afterwards altered and appears now. When these ships first commenced to run they were both fitted with three pole-masts with a gaff on each; but following the custom now adopted on many modern liners, one of the masts and all the gaffs have since been removed. It will be seen that a modified turtle-deck is still retained at the stern, and in one other respect this ship also continued the influence of the first *Oceanic*. It will be recollected that the latter possessed the enormous proportion of ten beams to her length. The *Teutonic* measured 582 feet long and 57·8 feet broad, so that she is only a few feet lacking in this respect. Her gross tonnage is 9,984, and her indicated horse-power 18,000. The *Majestic* broke the record by crossing

from Queenstown to New York in five days eighteen hours eight minutes; the *Teutonic* by doing the same journey in five days sixteen hours thirty-one minutes. If called upon, these ships could steam from Portsmouth to Bombay via the Cape of Good Hope, a distance of over 10,000 miles, in twenty-two days without having to coal on the way, a fact that might have some importance in the event of war breaking out.

In these two ships was also introduced the practice of overlapping the twin-screws, and in order that they might be able to clear the deadwood at the extreme end of the stern, a hole—technically called a "screw port"—was made after the manner in which a "port" is left for the screw to revolve when a vessel is provided only with a single propeller. The advantage in the case of the twin-screws was that they were allowed plenty of water for their propellers to revolve in. The advantage of the screws overlapping tended also to enable them to work in a manner as near as possible to the centre line of the hull.

The introduction of the twin-screw system was made in the Orient liner *Ophir* (see opposite page 166), which was built in 1891. Each of her four decks is of steel, and she was given the triple-expansion engines in two sets—one set for each propeller. She was the first vessel on the Australian route to be fitted with twin-screws, but many others have since followed and proved the wisdom of this innovation. Her propellers are made of manganese bronze, with three blades each, and give her a speed of between 18 and 19 knots. It will be recollected that it was this ship which was selected to carry the present King and Queen on their tour of the British Colonies in 1901.

The ceaseless competition in the Atlantic steamship progress

continued without abatement, and by now the Cunard Line was ready again to fight for the lead. In September of 1892 the *Campania* was launched, and was followed in the next February by the *Lucania*. Since their length was greater than the width of the Clyde, where they were built, they had to be launched into the river diagonally. They were, of course, fitted with twin-screws and with triple-expansion engines, there being five cylinders, of which two are high-pressure, one intermediate, and two low-pressure. We do not intend to weary the reader with a list of statistics which can easily be obtained by those to whom bare figures make their appeal; our purpose is served if we show in what important detail each successive vessel advanced the history of the steamship so as to approach more nearly to what is considered the ideal by modern experts. But we shall be shirking our duty if we do not indicate some of the main characteristics which gave to such a craft as the *Campania* a distinctiveness that distinguished her and her sister the *Lucania* from her contemporaries. One greatly improved liner nowadays so quickly surpasses her predecessor; the age of obsolescence now moves at so greatly quickened a speed; that the general public, whose memory is also so short-lived, scarcely has time to appreciate all that the latest steamship means ere it has passed quietly from service and been handed over to the ship-breakers, or, under a new flag and a changed name, continues its work at some remote corner of the world.

Those who remember seeing the *Campania* lying in the Mersey soon after she was commissioned, and with their minds full of the hitherto unparalleled features which had been foretold concerning her, will recollect that the first impression conveyed was identical with that made on seeing the *Mauretania*

THE "LUCANIA" (1893).

From a Photograph. By permission of the Cunard Steamship Co.

immediately after she had left the builders' hands. Not so much size but gracefulness; not the characteristics of a floating monster, but of a singularly beautiful creature whose every line suggested dignity with speed were the points that attracted one.

Handsome is as handsome does; these two sisters, one of which is no more, were not long in showing that their achievements were not belied by their good looks. In appearance less like "the biggest things afloat" than the most symmetrical colossal yacht, the *Campania* was built for business, and not primarily to be a thing of beauty. She has made the run between Queenstown and New York in 5½ days, and ocean travellers soon appreciated the important fact that in getting from one country to the other she had a reputation for regularity that would be hard to beat, irrespective of winter and summer weather. The *Campania* is slightly larger than her late sister, and has averaged just under 22 knots for a whole year's east-bound voyages. The engines of these elegant ships were arranged in the manner already indicated so as to avoid having unnecessarily large cylinders, the two high-pressure cylinders driving one crank, being arranged tandem fashion, the intermediate cylinder driving one crank, whilst the two low-pressure were also put the one above the other like the high-pressure, and by an ingenious contrivance it is possible to prevent the screws racing; for when the number of revolutions begins to exceed its proper limit the supply of steam is automatically cut off.

In order to render these boats less likely to roll in a sea-way, they were fitted with bilge-keels. They have, too, since been provided with wireless telegraph gear, whose aerials stretch from one mast to the other, and connect with the Marconi

cabin, and the up-to-date system of submarine signalling is also installed, so that in case of thick weather the sound waves transmitted from submerged bells on lightships outside Liverpool or New York may be conveyed to the ship herself below the waterline, and so by means of a telephone up to the officer on duty in the navigating room.

These two ships also marked another advance in method of building, for the steel plates from which their sides were made were of unprecedented size, and thus it is obvious that the number of rivets was considerably smaller. Opposite page 170 we give an illustration of the *Lucania* under way, and by comparing her with the earlier Atlantic liners, a fair idea will be obtained of the trend of steamship evolution. It will be noticed that the *Oceanic* turtle deck has gone, for the reason that since the stern had now become at such a height from the water it was hardly necessary. The topmost deck of the *Lucania* is the shade deck, and the one immediately below it the promenade deck; it should be noted that these two are not really part of the structure of the ship herself, but platforms superadded in much the same way as in a vastly different type of craft, the Viking ship, which, when it began to enter its transition state, had fighting platforms erected both at bow and stern so as to accommodate her men. The *Campania* measures 600 feet (between perpendiculars), with a beam of 65 feet 8 inches, and displaces nearly 20,000 tons. It was only in the early months of 1910 that the *Lucania*, her sister, after being on fire and compelled for that reason to be flooded with water, was sold out of the Cunard Company's service.

We come now to consider the entering of fierce competition from a quarter that hitherto had not affected the development

of the modern liner. We have seen that in spite of the efforts which America had put forth from time to time, the pride of the Atlantic Ocean had been British ultimately. The American-subsidised Collins Line had in the end to bow its head and yield, nor has the reorganised Inman Line (now the American Line) been a dangerous competitor in the matter of record passages. At different times first one British line of steamships pushed itself to the front, to be in turn ousted by its rival; and so the evolution of the steamship profited. But now it was to be not Britain, nor America, but Germany, which was to make a bold bid for the commercial sovereignty of Atlantic speed. Few phenomena are more notable within recent years than the sudden rise of Germany as a world power. In the realm of steamships there has been scarcely any parallel to the rapid development which that nation exhibited, so that within a remarkably short space of time she became able not merely to build her own ships, but of a size that had been exceeded only by the *Great Eastern*, and with a speed that no liner of any sort or of any nationality had ever yet attained. It is fitting, therefore, to give here a brief sketch of the manner in which this new competition originated, for to this undoubtedly is due the coming of the mammoth ships represented by the *Mauretania* and *Lusitania*. In the future this is the direction from which the quickening factor will come, as formerly it used to come from internal steamship organisations.

Modern German ship-building, like her other industries, dates only from the close of the Franco-Prussian War, and the birth of a united Empire. At the same time wood had already given way to iron, and a new era had begun in the making of ships. Great Britain possessed the exclusive confidence of shipping owners, and, speaking generally, if Germany wanted

a large ocean carrier built, she had to send her order across the North Sea, although steadily and gradually her national shipbuilding yards were growing up. But her designers and shipwrights lacked the knowledge which the British, through long years of experience, possessed. Since, however, the Germans were determined to engage in overseas trade, they had to obtain steamships, and these were made frequently on the Clyde, where so many other fine ships had first been seen.

But from the early 'eighties a new order of things began, and the Norddeutscher Lloyd commissioned a German firm to build the first Imperial mail steamers, which were also the first passenger steamers of large dimensions that the new Empire had yet constructed. Up till then Germany had built only two large passenger steamers, the displacement of each not exceeding 8,500 tons. The first German express steamer for the Norddeutscher Lloyd Company had been the *Elbe*, which was built at Glasgow, and began service in 1881, her tonnage being 4,510. During the 'eighties, spurred on by the competition which British steamships were arousing, the Germans endeavoured to build for themselves vessels of considerable proportions and send them on their long voyages. It is when we come to the 'nineties that we find the North German Lloyd Company entirely reorganising its fleet, scrapping the older-fashioned members, and, incited by the success which the *Campania* and *Lucania* had obtained, determined to produce from German yards such an express steamer as should surpass both of the Cunard vessels. In 1897, therefore, was built by the Stettin Vulcan Company the famous *Kaiser Wilhelm der Grosse*—of which a striking illustration will be seen facing this page. She was longer, wider, deeper and of greater displacement than the *Campania*, but her horse-power was

THE "KAISER WILHELM DER GROSSE" (1897).

From a Photograph. By permission of the Norddeutscher Lloyd Co.

inferior to the Cunarder's by 2,000. Nevertheless, the German outstripped the performances of the *Campania* and *Lucania* by attaining a mean speed of 22·81 knots, although her designed speed had only been 22·5 knots, and thus for the first time in the history of the steamship, the "blue ribbon" of the Atlantic passed over to Germany. Like the Cunard ships, the *Kaiser Wilhelm der Grosse* was installed with two sets of triple-expansion engines, and it had been expressly agreed between the Norddeutscher Company on the one hand, and the Vulcan Company on the other, that the ship was first to run a trial trip across the Atlantic to New York, and, if during this she did not come up to the requirements of the contract, then the Norddeutscher Lloyd were to be free to reject the ship. Such a condition as this was as severe as could ever be invented by any steamship line. However, she not merely came up to specifications, but even surpassed them, and remains one of the most efficient liners traversing the North Atlantic.

This steamship was built with flaring bows so as to increase her buoyancy forward, and is propelled by twin-screws. Another instance of the advantages which the latter possess as a means of ensuring the safety of the ship was exhibited as recently as October, 1907. Whilst coming across the Atlantic in that month the *Kaiser Wilhelm der Grosse* chanced to fracture her rudder. The weather was bad, and it was blowing a gale, but her skipper instead of running for the nearest port, which was Halifax, distant about 700 miles, brought her home safe and sound to Bremerhaven, another 2,800 miles, calling at Plymouth on the way. By means of the twin-screws the ship could be manœuvred quite independently of the steering gear. The measurements of this ship are as follows: length over

all, 648 feet 7 inches; beam, 66 feet; moulded depth, 48 feet; gross tonnage, 14,349; indicated horse-power, 28,000.

The British reply to the *Kaiser Wilhelm der Grosse* came not in speed but in size, for it is not always realised how costly it is to get an extra knot or two out of a big steamship, and that such an attainment is out of all proportion to the expense which this has involved. At high speeds the resistance of the ship, of which we have already said something, increases far more rapidly than it does when the speed through the water is slow or even moderately fast. When a ship reaches the speed of 20 knots the influential factor of wave-making comes in prominently. Furthermore, in order to coax an extra knot or two out of the ship, you must needs increase her weight and usurp a very serious amount of space by larger engines and boilers. Therefore, the answer to the German attack was seen in the comparatively slow White Star *Oceanic*, the second steamship of that name sailing under the same flag. This modern ship was the first vessel which exceeded the length of the *Great Eastern*, and is about 18 feet longer, though about 14½ feet narrower than Brunel's craft. True to the White Star type, the latest *Oceanic* is ten beams, and even more, to her length, her measurements being 705 feet long over all, 68·4 feet wide, a draught of 32½ feet, and the terrific displacement of 28,500 tons, that of the *Great Eastern* having been 32,000. Like the other great Atlantic liners since the *City of Paris*, this *Oceanic* was fitted with two sets of triple-expansion engines driving twin-screws; she began her voyaging at the end of 1899. As will be seen from the accompanying photograph, in spite of her magnitude, she is so beautifully designed that there is nothing in the least out of perfect proportion. Some idea of the number of tiers possessed by the *Oceanic*, rising

THE "OCEANIC" (1899).

THE "CEDRIC."

From Photographs By permission of Messrs. Ismay Imrie & Co

high above the water, may be gathered if we enumerate them singly. Looking at the illustration, and beginning from the top, there is the captain's bridge towering 43 feet above the sea. Eight feet below comes the boat deck, and below that the promenade deck, and lower still the upper deck. Then the first line of port-holes shows the extent of the middle deck, and the next line the lower deck. In addition to these five decks which stretch from one end of the ship to the other there are two partial decks, the orlop and lower orlop respectively. Like other modern steamships, the *Oceanic* has a double bottom, sub-divided into so many cells. She has been built with the intention of being used, if necessary, as an auxiliary cruiser, and was designed with the necessary additional strength. Keeping up an average speed at sea of about 20 knots, this great ship is not compelled to drive headlong into whatever weather may be waiting for her. The absence of extra powerful engines also means the absence of that unpleasant vibration which is not unknown to some of the "flyers" that tear across the ocean in a hurry to get their passengers and mails to port. It will be noticed on examining this illustration that, unlike the case of her namesake, the turtle decks have disappeared altogether, the reason being, as already pointed out, that the hull is so high above the water as not to need these. In spite of her great length, the *Oceanic* is not so unhandy as she might seem. Her forefoot is well cut-away, and this, in addition to the proper employment of her twin-screws, enables her to be manœuvred with a facility that is a little surprising.

The Cunard Company resting content with the performances of their express steamers *Campania* and *Lucania*, still left the *Kaiser Wilhelm der Grosse* to maintain the reputation for

pace, and, following the example of the White Star Line, built in the *Ivernia* and *Saxonia* a couple of steamships of great size but comparatively moderate speed. The *Ivernia* is two feet shorter than the *Majestic*, but her gross tonnage comes out at 14,027, making her in this respect but little inferior to the *Kaiser Wilhelm der Grosse*, though superior to the latter in displacement tonnage. The *Ivernia's* speed averages about 15½ knots; she came into being in 1899. These vessels belong to a class of steamship which has grown up under the title of "intermediate," its origin being based on the assumption that a comfortable, economical, moderately fast type of ship would be able to find appreciation no less than the high-powered ships. Both the *Ivernia* and *Saxonia* have considerable capacities for cargo as well as passengers, and are characterised by their exceptionally low coal consumption. They are single-funnelled boats, and engaged on the Liverpool-Boston route. But the *Ivernia* was the first of the Atlantic liners to break away from the triple-expansion system and to be installed with the more modern quadruple-expansion type of engine. This being the same principle as the triple-expansion pushed one stage further, using four instead of three cylinders, we need not stop to explain what is already clear in the mind of the reader.

Two other of these "Intermediates" were added to the White Star Line in 1901 and 1903 respectively. These are the *Celtic* and *Cedric*, and a photograph of the latter will be seen opposite page 176. Only in regard to speed have these handsome vessels the slightest right to be designated "intermediate." They both possess a tonnage about twice that of the *City of Paris*, for the *Celtic* is 20,880, and the *Cedric* 21,034 tons, and the speed of each is 16 knots. Speed is not the main

THE "CELTIC."

From a Photograph. By permission of Messrs Ismay Imrie & Co.

consideration to those who have the slightest affection for ships and the sea. The beautiful motion of the *Cedric*, for instance, in a winter's Atlantic gale, rolling and pitching in a manner just enough to show she is a living ship and not a dull, lifeless steel box, pursuing her way with boldness and dignity, caring little for the great waves mounting up astern, is a delight that lives long in one's memory. She has no need to break her neck hurrying and scurrying, trying to become a large-sized submarine; she prefers to go *over* the sea rather than through it, and this with a movement that is comparable to that of a well-bred lady gliding along smoothly and with dignity.

From the owners' point of view these are economical ships to run, for with 16 knots the coal consumption is very moderate, whilst at the same time their size enables them to carry large numbers of passengers and considerable quantities of cargo. As evidence of the remarkable evolution in type, I would ask the reader to compare the accompanying illustration of the *Cedric* with that of the *Great Eastern*. Both are of about the same length, although the latter was about 8 feet wider, and at the time of her launch the *Cedric* was the largest ship of any kind that had hitherto been constructed. Another "intermediate," the *Arabic*, followed in the same year, possessing the same speed of 16 knots, but a tonnage only of 15,801. This is one of the vessels employed on the Liverpool-New York route, the Southampton-New York White Star service being supplied by the *Adriatic* (to which I shall refer presently), together with the *Oceanic*, the *Majestic* and the *Teutonic*.

The German success in the *Kaiser Wilhelm der Grosse* was now to be followed up by a still more wonderful achievement in the *Kaiser Wilhelm II.*, a photograph of which is

here reproduced. Her coming in 1903 caused a sensation in the shipping world, for she represented not merely the extraordinary capabilities which the German shipbuilders had already attained, but was superior in speed not only to all the British steamships, but to her own sister, the *Kaiser Wilhelm der Grosse*. Two and a half feet longer than the *Oceanic*, about 4 feet wider, but with 5 feet less depth, she was, like the *Ivernia*, fitted with two sets of quadruple-expansion engines to drive her twin-screws. Her gross tonnage exceeded that of the *Oceanic* and the *Great Eastern* as well, and with a speed of 23½ knots was a knot faster than the *Kaiser Wilhelm der Grosse*. This vessel and the Hamburg-American liner *Deutschland* were able to give to Germany the proud possession of the fastest liners in the world until the *Lusitania* arrived on the scene. The *Kaiser Wilhelm II.'s* best day's run is 583 knots, and she has maintained an average speed from New York to Plymouth of 23·58 knots. To obtain this the phenomenal amount of 45,000 horse-power has to be developed by means of a double set of quadruple-expansion engines—two for each propeller shaft—necessitating sixteen cylinders, steam being generated from nineteen boilers fired by no fewer than 124 furnaces. But no one could assert that such a ship as this is economical to run, for although her speed is only one knot faster than the *Kaiser Wilhelm der Grosse*, yet each day she burns about another 200 tons of coal in doing it, and supposing we were to take the cost of fuel at 20s. a ton, we can easily see that each Atlantic voyage means an *extra* expense of much more than £1,000.

Now, since the steamship is run for the purpose of making money, it is essential that over-seas trade should not show any signs of lagging; otherwise it becomes commer-

THE "KAISER WILHELM II."

From a Photograph by West & Son, Southsea

cially impossible to run these fast ships from one continent to the other. The craze for speed is one that may go on and on for just such a time as the financial support continues; but as soon as a diminution in trade sets in, and with it a falling-off in revenue, this wild, reckless race for speed-supremacy must automatically cease. At present it is but a reflection of the restless activity on shore. May the time not come when rest and simplicity will again replace excessive strenuousness and restore to the Atlantic something of its plain expansiveness, and take back the character which it has now developed as being merely a race-track for ocean greyhounds? However much designers, shipbuilders and engineers may conspire together; whatever inventions man in his brilliant efforts may succeed in bringing about, the solid fact remains that Nature is superior in force to all these. The winds will blow and the great seas will roll up against all the mighty ships man may build. Among the gifts to humanity there is not included that of taming the sea. She is tyrannical in her strength, untamable, dominant; and when you launch into her bosom heavy masses of iron or steel, and deceive yourself with high-sounding names—call them *Great Easterns, Majestics, Indomitables, Titanics,* and the rest—the Sea only laughs at you, for she knows perfectly well that a blow or two from her mighty arm will end their days and settle their fate for all time. To fight against Nature is to contend against heavy odds, to engage in a contest whose result is known long beforehand; and the most that man can ever do is make a truce with his superior foe, so that he may be able to rush across her expanse much as he would hurry past the open cage of a tigress. For that reason speed is appreciated by some as the greatest weapon which was ever given to the ship, but even then it

cannot terrify a much mightier power. In spite of wireless gear, submarine bells, navigational science, expert seamanship, perfect ship-building and design, well-found ships still put to sea and disappear presently never to be seen again. The case of the *Waratah* is not an isolated incident, but an example of the universal law that human achievement in comparison with the eternal sovereignity of the Sea must take only a second place, and learn to obey, when bidden, a power of far older, far superior strength.

CHAPTER VII

THE MODERN MAMMOTH STEAMSHIP

In the history of the steamship during the short space of time that she has been employed, the changes in connection with her have followed with singular celerity. We have, during the previous pages, witnessed in the material of which she is built the gradual transition from wood to iron and steel; we have seen how steam pressures became greater, and the ensuing introduction of the compound system, the triple-expansion and the quadruple. We have also watehed the change from paddle-wheels to a single screw, and thence to twin-screws. Each change has seemed to be so excellent in its nature, so beneficial in results, that almost on each occasion we might have thought that finality had been reached. At times our minds have been wearied with the constant reiteration of the latest wonders, and our imaginations have found some difficulty in responding to the demands which one invention after another has put forward. It has all happened within so short a time, and on a scale of such unheard-of magnitude, that scarcely have we been able to find expressions adequate to our subject.

But now we enter upon what is the most wonderful of any period since the steamship came into the world, and for this we have to thank the introduction of the turbine, merely the beginnings of which we are now watching; whose influence, not merely in the engineering world generally, but in the domain of the steamship particularly, is already marking,

in the most certain manner, a distinct cleavage between the things of yesterday and those of to-morrow. The turbine is only in its infancy, yet since its infantile influence has caused already so great a revolution, one hesitates to reckon what it will do before it is as old as the old-fashioned reciprocating engine, whose history we have outlined. Its modern practical invention is due to two men, one an Englishman, the other a Swede, who during the early 'eighties made their systems public. The latter is Dr. Gustav de Laval; the former the Hon. Charles Algernon Parsons, son of the Earl of Rosse, who after a distinguished career at Cambridge, where he graduated as eleventh Wrangler, brought out this new method in 1884. Five years later Dr. de Laval, working at the same problem, developed a somewhat similar engine. We have spoken of the *modern* invention advisedly, for there is nothing new under the sun, and we shall see that the bare principle is hundreds of years old. In its simplest form, the turbine is similar to a water-wheel, a jet of steam taking the place of water. As far back as 1629, Giovanni Branca, an Italian engineer, had suggested much the same thing, and if the reader will now refer to the illustration opposite he will be able to gain some idea of the form in which his idea took shape.

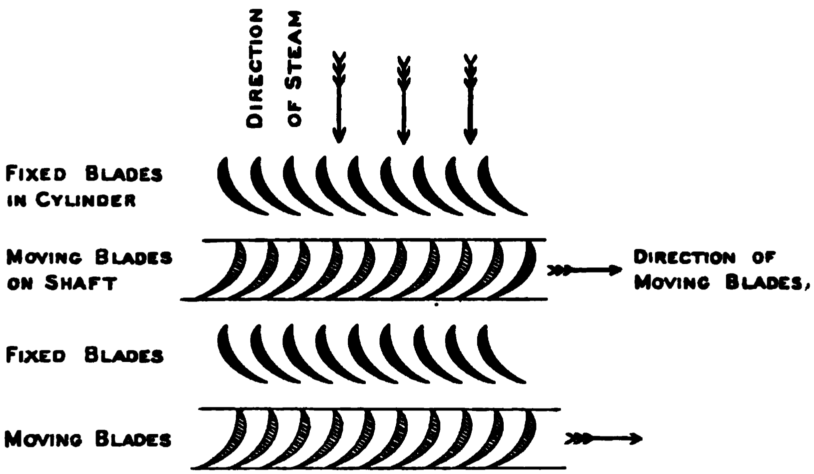
Steam was to be raised as usual, by applying heat to a vessel containing water. (In the picture this vessel is seen to be in the shape of a man's head and neck, the steam, so soon as it is formed, issuing out of his mouth. The original illustration was published in *Le Machine* by Giovanni Branca, printed in 1629, and containing all sorts of most interesting labour-saving devices, such as the employment of winches, chain-pumps, water-wheels, water-buckets and pumps of many kinds.) As the steam escaped it was directed against the vanes

GIOVANNI BRANCA'S STEAM ENGINE (1629).

The simplest form of Turbine.

From the Exhibit in the Victoria and Albert Museum.

on the circumference of a wheel fitted with little fans like a water-wheel, and so causing it to revolve. In the picture the wheel is being utilised by means of gearing for lifting pestles. Speaking generally, this resembles roughly the idea of the de Laval turbine, but in actual application de Laval allows the steam to issue through one or more nozzles placed as close



THE BLADES OF A PARSONS TURBINE.

By permission of Messrs. C. A. Parsons & Co., Newcastle-on-Tyne.

as one-sixteenth of an inch to the blades or fans, so that every particle of steam shall strike a blade.

But the Parsons system differs in detail from this, and employs a number of wheels mounted on the same shaft, the steam entering at one end, working its way along and expending its energy to each wheel as it passes. If the reader will examine the illustration facing page 186, he will see a section of one of these turbines, which is here reproduced through the courtesy of Messrs. C. A. Parsons and Co. But before we deal with the actual working of this, we would also call attention

to the drawings on page 185, which depict alternate rows of fixed and moving blades. Steam enters the turbine in a direction parallel with the axis of the shaft, and flows through the length of the turbine in a zig-zag fashion. Looking at the top line in this diagram, we see a row of fixed discs or blades sloping in one direction, on to which the steam pours. These, so to speak, reflect the steam so that it passes at right angles from the slope of the fixed blade to the first row of moving blades which are on the shaft, thus giving them and it a rotational force in the direction indicated by the arrow. But the curved shape of the moving blades causes the steam to issue from them in a direction exactly opposite to that in which it had entered, and thus the reaction gives additional rotational force to these moving blades. The steam now reaches the next row of fixed blades and repeats the same action again on the next row of moving blades.

Turning now to the illustration of the turbine facing this page, let us see how this applies in actuality. This sketch represents a section of a cylindrical case with rows of inwardly projecting blades, and within this cylinder revolves a shaft with outwardly projecting blades. Steam enters at the point marked *A* on the lower half of the cylinder, and then passes through the different rows of fixed and moving blades, as previously explained, finally leaving the cylinder at the exhaust pipe, marked *B*. But it will be noticed that the diameter of the shaft varies in three different stages, the reason for this being that a method analogous to the compound method in the triple-expansion engines is here employed. Thus the whole expansive force of the steam is not converted into speed all at one stage, but working its way along, expands as it goes. It should be added that the fixed blades are on the case of

THE PARSONS TURBINE.

By permission of Messrs C. A. Parsons & Co.

the cylinder, but the moving blades are on the rotor (or rotating part, consisting of a hollow steel drum), the steam rebounding from the fixed blades to the moving ones much as one billiard ball cannons off another.

The cylindrical case is divided horizontally, and can be taken off, so that the blades may be got at. The illustration facing page 188 shows the lower half of the fixed portion or cylinder of one of the *Carmania's* turbines. The blades themselves are made either of brass or copper, and are caulked one by one into grooves in the cylinder and shaft, but a newer method enables them to be assembled in complete sectors ready for insertion. The Allan Line turbine-steamer *Virginian* contains no fewer than 750,000 of these blades on the rotating part, but together with those which are fixed, they total a million and a half, the diameter of the largest blade being 8 feet 6 inches.

Such, briefly, is the principle of the new form of engine which is causing so thorough an alteration in the means of propelling the steamship. Practically all the turbine craft are of the Parsons type. For some years this system was employed for driving electric dynamos on land, for pumping stations, colliery fans and the like, but in 1894 it was first installed in the now celebrated little ship, the *Turbinia*, which was built for the purpose of exhibiting the capabilities of the turbine. She was of only 44 tons, developing 2,000 horse-power, but those who happened to see her racing along the water at Spithead, doing her 34 knots without distress, were in no further need of conviction as to her speed abilities. But therein lay the drawback; the difficulty at first was to obtain such a speed as should be suitable for slow-going vessels, though we shall see that this difficulty is now disappearing.

Another great fault of the turbine is that it can only go one way, so that in order to enable a ship to go astern, she has to be fitted with an additional propeller and turbine, the blades in the latter being placed in the opposite way; when the ship is going ahead, these just revolve idly. In practice it is usual to employ two propellers and turbines for going astern instead of one. For driving other than fast ships the turbine was found not to be economical, but the reader may ask the question: "Why not let the ship go fast? Why detain her, if she is anxious to get to port?" The answer is that she wouldn't get there as fast, for the reason that unless the ship is designed to travel at very high speeds, the propeller, revolving at a great rate, loses its efficiency; for, instead of being able to use the water, much as an oarsman uses the water for his oar to get a good grip, the water is simply carried round with the screw. In order to counteract this failing, therefore, it has been suggested that the turbine should not drive the propeller direct but drive a dynamo, the current from which should actuate electric motors for such a speed as will suit the propellers. With this would also vanish the reversing difficulty, for a motor is easily reversible. But a paper was read by the Hon. C. A. Parsons, the Vice-President, at the annual meeting of the Institution of Naval Architects, in March, 1910, in which he gave particulars of a scheme to enable a high-speed turbine to be suitable for a low-speed tramp steamer. As Mr. Parsons' theory has actually been put into practice, and will no doubt be found to be the solution of the problem, we may here outline so interesting an experiment. In a word, the method employed is just that which we saw was used in those early days, when the screw engines were first brought in. As the reader will recollect, the difficulty

THE "CARMANIA" (1905).

LOWER HALF OF THE FIXED PORTION OF ONE OF THE "CARMANIA'S" TURBINES.

From Photographs. By permission of the Cunard Steamship Co.

was then overcome by means of gearing, instead of the engines working directly on to the shaft; so, in principle, at least, is it in the present instance.

With a view of putting to a test turbines mechanically geared to the propeller shaft, an old screw steamer, named the *Vespasian*, was purchased in 1909. She was built in 1887, and has a displacement of 4,850 tons. Originally, she was fitted with ordinary triple-expansion engines, and before making any alterations it was decided to run trials with those engines in use. But in order that these should show their best performances, they were overhauled, and rendered thoroughly efficient. It was further decided, in order that the proper data under service conditions might be obtained, that she was to be run properly loaded. Arrangements were therefore made with a firm of shipbrokers to take a cargo of coal from the Tyne to Malta, and during this voyage a special recording staff on board made careful measurements of the coal and water consumed. She then returned to the Turbinia Works, and her triple-expansion engines were taken out, and in their place were installed two turbines, one high-pressure and one low-pressure, the former being placed on the starboard side, the latter to port, a reversing turbine being incorporated in the exhaust casing of the low-pressure turbine. By means of mechanical gearing the power was conveyed from the turbine to the shaft, and without having made any alterations to the propeller, the vessel was loaded again to her proper trim and sent out to sea in February, 1910. The results are significant, and may be summed up thus: the *Vespasian* was found to possess under normal full-speed conditions an increase of about one knot per hour owing to the higher efficiency of the turbine, but with reduced water-consumption, and consequently

coal consumption, amounting to nearly 20 per cent. Further, the weight of the reciprocating engines was 100 tons; that of the turbines is only 75. Thus the ship is enabled to carry a larger amount of cargo, whilst simultaneously she effects a saving in coal, in oil, in engine-room staff and in up-keep. Mr. Parsons asserts that the turbines and gearing have given no trouble, have caused very little noise or vibration, and there is no appreciable wear on the teeth of the gearing.

To the Allan Line belongs the honour of having been the first to introduce the turbine upon the Atlantic, and at the beginning of the year 1905, the *Victorian* and *Virginian*, which had been contracted for two years earlier, began running. These two ships are employed on the Liverpool-Montreal service, and were built to be of as great a size as safe navigation of the river St. Lawrence would permit. They displace 12,000 tons each, and are fitted with Parsons triplicate turbines, driving three independent shafts and maintaining a speed of 17 knots average; but on her trials the *Virginian* attained a speed of 19·8 knots, and the *Victorian* 19·2 knots. Three propellers are used for steaming ahead, and two low-pressure turbines are employed for manœuvring either ahead or astern; these are provided with a supplementary turbine for going astern. When going ahead, the steam is first used in the high-pressure turbine engine and then allowed to flow therefrom to the two low-pressure turbines, after which it passes to the condensers. Owing to the turbine system the vibration is reduced to a minimum, and since it is possible, from their nature, to place the turbine engines very low in the hull, it follows that the screws also can be placed very low. The practical effect of this is that the propellers are rarely out of the water in a heavy sea, and so the objectionable "racing"

disappears. The *Virginian* soon showed that she was not merely a comfortable, but a comparatively fast ship, for she made an eastward trip in the shortest time hitherto occupied between Canada and England.

In the same year the Cunard Line followed with the *Carmania,* their first turbine liner, fitted with three turbines and three screws. She was preceded a little by the *Caronia,* a sister ship in every way except that the latter is propelled by two sets of quadruple-expansion reciprocating engines, driving twin-screws. These ships have a displacement of 30,000 tons, and a length over all of 675 feet. They were built of a strength that was in excess of Board of Trade and other requirements, and when we state that no fewer than 1,800,000 rivets were used in the construction of each, one begins to realise something of the amount of work that was put into them. Their steel plating varies in thickness from three-quarters of an inch to an inch and an eighth in thickness, the length of each plate being 32 feet. Fitted with a cellular bottom which is carried well up the sides of the ship above the bilges, they can thus carry three and a half thousand tons of water-ballast. The principles underlying the design and construction of these ships were steadiness and strength, and in the attainment of this they have been eminently successful. There are eight decks, which may be detailed by reference to the photograph of the *Carmania* facing page 188. Immediately below the bridge is the boat deck. Then follow successively the upper promenade deck, the promenade, the saloon, upper, and main decks. Below the water-line come two other decks for stores and cargo, the depth from the boat deck being eighty feet. Both of these ships are fitted with the now well-known Stone-Lloyd system of safety water-tight doors, which renders the vessel

practically unsinkable. This enables the doors to be closed by the captain from his bridge, after sufficient notice has been given by the sounding of gongs, so that everyone may move away from the neighbourhood of these doors. But should it chance that, after they have been shut, any of the crew or passengers have had their retreat cut off, it is only necessary to turn a handle, when the door will at once open and afterwards automatically shut again. The system is worked by hydraulics, and is a vast improvement on the early methods employed to retain a ship's buoyancy after collision with an iceberg, vessel or other object. A glance at the illustration will show that a very great amount of consideration was paid to the subject of giving the *Carmania* a comprehensive system of ventilation, a principle which has been carried still further in the *Mauretania* and *Lusitania*.

In the event of war the *Carmania* and *Caronia* would be fitted with twelve large quick-firing guns, for the hulls were built in accordance with the Admiralty's requirements for armed cruisers. For this reason, also, the rudder is placed entirely under water, and besides the ordinary set of steering gear, there is another placed below the water-line.

On her trials the *Carmania* attained a speed of over 20 knots, and the saving in weight by adopting turbine engines as compared with the *Caronia's* reciprocating engines was found to amount to 5 per cent. In actual size these fine ships are inferior to the *Great Eastern*, but they were built with meticulous regard for strength, and needed 2,000 tons more material than was used in the old Brunel ship. The arrangements of the *Carmania's* turbines are worthy of note. There are three propellers and shafts. That in the centre is the high-pressure turbine, whilst the "wing" (or two side) turbines placed

A STUDY IN COMPARISONS: THE "MAGNETIC" AND "BALTIC."

From a Photograph by permission of the London & North Western Railway.

respectively to starboard and port are the low-pressure and astern turbines. Steam is supplied by eight double-ended and five single-ended boilers, which are fitted with Howden's system of forced draught. This latter enables the air to be heated before it enters the furnace, and was patented in 1883. It is also in use on the *Mauretania*.

The beautiful picture facing page 192 was taken in Holyhead Harbour in June, 1909, and is a study in comparisons. At the left, first come the two small steam craft, then the White Star passenger tender, the *Magnetic*, a twin-screw steamer of 619 tons, and, finally, the other White Star twin-screw mammoth *Baltic*, of 23,876 tons. The *Magnetic* happens to be less than 100 tons smaller than the little *Sirius*, which was the first steamer to cross the Atlantic entirely under steam power in 1838. Therefore, if we but imagine in place of the twin-screw tender the paddle *Sirius*, we can form some fairly accurate idea of the extent to which the Atlantic steamship has developed in less than seventy years, a development that neither Fulton nor anyone else could have foretold in their wildest flights of imagination. This *Baltic*, with her 24,000 tons, is one of the largest vessels in the world—about 9,000 tons larger than Noah's Ark, if we take the Biblical cubit as equal to a foot and a half, which makes that historic craft about 15,000 tons register. The *Baltic* has a length of 725¾ feet; the Ark measured 450 feet in length. The *Baltic* can carry with the utmost ease and luxury 3,000 passengers, as well as 350 crew. Just how many animals she could put away in her holds as well, if called upon, I do not know; but in any case it would be able to put up a keen competition with the capacities of Noah's craft.

Here, again, we find a White Star ship excelling not in

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speed, but in size, for she was designed to do only 16½ knots at the outside. She is propelled by quadruple-expansion engines. She made her appearance in 1905, and is additionally interesting, as she exhibits a slight divergence from the ten beams to the length principle, which governed for so long a time the White Star ships; to come up to this rule this vessel would have to be another 80 feet in length.

We have already explained the reason which underlies the comparatively moderate speed of these ships, and mentioned that the question of economical steaming was at the root of the matter. As an example we might quote the case of the *Majestic*, belonging to the same line, as an instance. This vessel consumes 316 tons of coal per day to get a speed of 19 knots; the *Baltic*, a vessel nearly twice and a half the size, requires only 260 tons of fuel a day for her 16½ knots.

And so we come to those two leviathans which form, without exception, the most extraordinary, the most massive, the fastest, and the most luxurious ships that ever crossed an ocean. Caligula's galleys, which were wondrously furnished with trees, marbles and other luxuries which ought never to desecrate the sweet, dignified character of the ship, were less sea-craft than floating villas exuding decadence at every feature. There are some characteristics of the *Mauretania* and *Lusitania*, with their lifts, their marbles, curtains, ceilings, trees, and other expressions of twentieth century luxury, which, while appreciated by the landsman and his wife, are nauseating to the man who loves the sea and its ships for their own sakes, and not for the chance of enjoying self-indulgence in some new form. But all the same these two Cunarders are ships first, and floating mansions only in a secondary sense. They

are even more than that: they are ocean-greyhounds of a new breed with a pace that surpasses any other of the mercantile sea dogs.

These two historic craft are regarded in different ways by different people. You may think of them as hotels, you may look at them as representing the outcome of the greatest minds in naval architecture, ship-construction and marine engineering. Or, again, you may reckon up how much capital is tied up within their walls, how much material they have eaten up, how many hundreds of men they have given, and are giving, employment to. But whichever way you regard them, from whatever standpoint you choose, there is nothing comparable to them, there are no standards whatsoever by which to judge them. We can only doff our hats to the organising and originating geniuses who in one way or another brought these marvels from out of the realm of impossibility to the actuality of the broad Atlantic. Cover them with tier upon tier of decks, scatter over them a forest of ventilators, roofs and chimneys, till they look like the tops of a small town; fill them inside with handsome furniture, line their walls with costly decorations; throw in a few electric cranes, a coal mine, several restaurants, the population of a large-sized village and a good many other things besides; give them each a length equal to that of the Houses of Parliament, a height greater than the buildings in Northumberland Avenue, disguise them in any way you please, and for all that these are *ships*, which have to obey the laws of Nature, of the Great Sea, just as the first sailing ship and the first Atlantic steamship had to show their submission. I submit that to look upon these two ships as mere speed-manufacturers engaged in the record industry, as palatial abodes, or even as dividend-earners is an

insult to the brains that conceived them, to the honourable name of "ship" which they bear.

The *Mauretania* and *Lusitania* are the outcome of an agreement made between the British Government and the Cunard Steamship Company, in which it was contracted to produce two steamships "capable of maintaining a minimum average ocean speed of from 24 to 25 knots an hour in moderate weather." In every way these ships have exceeded the dimensions of the *Great Eastern*. There was no precedent for them in dimensions, engine power, displacement or aught else. It was not to be expected that such gigantic productions as these could be the outcome of one mind; such a thing would be impossible. It was only as a result of an exhaustive inquiry made on behalf of the Cunard Company by some of the most experienced ship-builders and marine engineers of this country, aided by the constructive and engineering staff of the Admiralty, as well as by the preliminary knowledge derived from models, that the best form for obtaining this unprecedented speed was evolved. Whatever was best in existing knowledge or materials was investigated. A special committee, representing the Cunard Company, the Admiralty and private industries went deeply into the question of engines; and with right judgment, and, it must be said, with no little courage and enterprising foresight, decided, after conferring with Mr. Parsons, to choose turbines, applied to four shafts, each carrying a single screw.

These two absolutely unique steamships differ entirely from the previous fast liners that we have enumerated, as well as from those large "intermediates" with moderate speed. The size of these mammoths was decided upon, not with reference to their cargo-carrying capacity—for they have

practically no space for this—but in order to be able to steam at an average speed of 25 knots in moderate weather for 3,000 miles, to carry enough coal to last them the voyage when consuming about a 1,000 tons per day, and to carry an adequate number of passengers to allow the ships to pay their way. It was impossible, therefore, to have given them any smaller dimensions. I make this statement on the authority of no less an expert than Sir William H. White, K.C.B., the illustrious naval architect who was connected so closely with the birth of the *Mauretania*. It was a happy coincidence that the turbine had already shown itself capable of so much that to employ it in these ships seemed a justifiable experiment. For otherwise, in order to obtain the requisite speed the vessel could not have contained the large amount of propelling apparatus. The working speeds of these two ships exceeds by 1½ knots the highest speeds ever attained in the Atlantic service. Had the reciprocating engine been employed instead of the turbine there would have been serious risk of troublesome vibration, the shafts would have had to have been of very large dimensions; large-sized propellers would have been necessary, and these latter, of course, would have been unfavourable to high efficiency of propulsion, whilst with the more rapidly revolving turbine the screws are still of moderate diameter. But apart altogether from the questions of economy of space, liability to accident and so on, there was a national consideration to be reckoned. This country has now for many hundreds of years prided itself on being the mistress of the seas, a title that was only won after serious, hard struggles. Although that title has reference rather to matters immediately connected with the Royal Navy, yet national industry and a series of private enterprises had, as we have seen, given us also an analogous position in regard

to our mercantile marine. This was until the German *Kaiser Wilhelm der Grosse*, followed by the *Kaiser Wilhelm II.* and the *Deutschland*, took away—in speed, at least—this title. It was, therefore, a matter affecting our honour and our pride that we should put on to the water some ship or ships that should be capable of winning back the "blue ribbon" of the Atlantic, and restoring to us the supremacy of speed at sea. There is, however, a more practical consideration. Without the assistance of the Government it would have been financially impracticable even for so wealthy a corporation as the Cunard Company to cause such a couple of ships as these to be built. And yet it was worth while that the nation should help the Company, for in the event of war breaking out between us and another first-class nation, it would not be long before we should be starved into submission if by any chance our over-seas food supply were cut off. It has been suggested with every appearance of probability, that in such a condition the *Mauretania* and *Lusitania* might render the highest service by making rapid passages across the Atlantic and, being there loaded up with grain, might hurry back home again. Their speed alone would save them from the enemy, except perhaps from the latest and fastest types of fighting-ships. But if convoyed by the *Indomitable* and *Invincible* battleship-cruisers, with their enormous speed and equally enormous "smashing power," the chances would be in favour of the grain-ships reaching port. Thus when the British Government advanced the sum of £2,000,000 sterling (which amount represents about one-half of the total cost of the two vessels) it was acting with a wisdom and a power for looking well ahead that is not always possessed by political bodies. With their very considerable capacities for passenger accommodation, these

THE "MAURETANIA," WHEN COMPLETING AT WALLSEND-ON-TYNE.

From a Photograph. By permission of the Cunard Steamship Co.

two ships would also be invaluable if called upon to act as transports.

The singularly impressive picture facing page 198 shows the *Mauretania* whilst she was still lying on the Tyne at Wallsend before being quite ready for service. It is by a happy coincidence that the same picture shows a delightful contrast between this last word of modern invention and the old-fashioned type of steam tug-boat in the river, to the right. There is, in fact, so mighty a divergence in character that it is not easy to catalogue both under the very elastic and comprehensive title of steamship. Only by comparison with existing ships can one gain any idea of the *Mauretania's* colossal qualities. The present writer was one of those who watched the *Mauretania* docked for the first time at Liverpool immediately after she had come round to the Mersey from the Tyne. By her was lying another steamship, by no means out of date, whose appearance at one time called forth some of the expressions of amazement and wonder that these two Cunarders have brought about. For size and speed this older "greyhound" was properly and legitimately famous, but yet within the comparatively small dimensions of the dock-space one was able to obtain a more accurate idea as to the exact proportions of the *Mauretania* than when lying outside in the river, where space brings with it deception; and it was amazing to remark how utterly and unconditionally the new steamship overshadowed the old. Even in such close proximity as one stood, everything else looked small by comparison. The captain on the *Mauretania's* bridge resembled a small, black dot, the funnels looked like four great, red caverns. A brand new thick rope warp was brought to the shore to stop the *Mauretania's* way. It was so heavy that a score of men were needed to move

it about. And yet although she seemed scarcely to be moving the liner broke it in two just as a toy model breaks a piece of cotton. Or, again, one may look at this same ship lying at her mooring buoy on the Cheshire side of the Mersey and be lost in wonder at her graceful curves. With such sweet lines you could not doubt that she was also speedy. But it is not until one sees a good-sized steam-tug go shooting by the buoy that one obtains any idea as to measurements. The buoy is as big and bigger than the tug, and, therefore, how many more times must the liner herself be bigger than the tug? You see another steamer alongside this mountain of steel and the steamer is nothing remarkable. But presently as she comes down by the landing-stage, past a smaller liner brought up to her anchor in the middle of the river, you find that that little steamer is several sizes bigger than a moderate coaster. It would have been so easy to make this finest ship in the world look also the largest; it is a much finer achievement to have made her look, what she is, the handsomest.

Passing then to some of the details of these leviathans, we find that they measure 790 feet long, 88 feet broad, whilst the depth from the topmost deck to the bottom is 80 feet. Choose out some high building or cliff 150 feet high, and it will still be 5 feet less than the height of these ships from the bottom to the top of their funnels. Their displacement at load draught is 40,000 tons; they each develop 68,000 horse-power, and draw, when fully loaded, 37½ feet of water. When crew and passengers are on board each ship represents a community of 3,200 persons. They are fitted with bilge keels, double bottoms, water-tight doors, and there are eight decks in all. To hold such massive weights as these ships exceptionally powerful ground tackle is necessitated. The main cable alone

STERN OF THE "MAURETANIA."

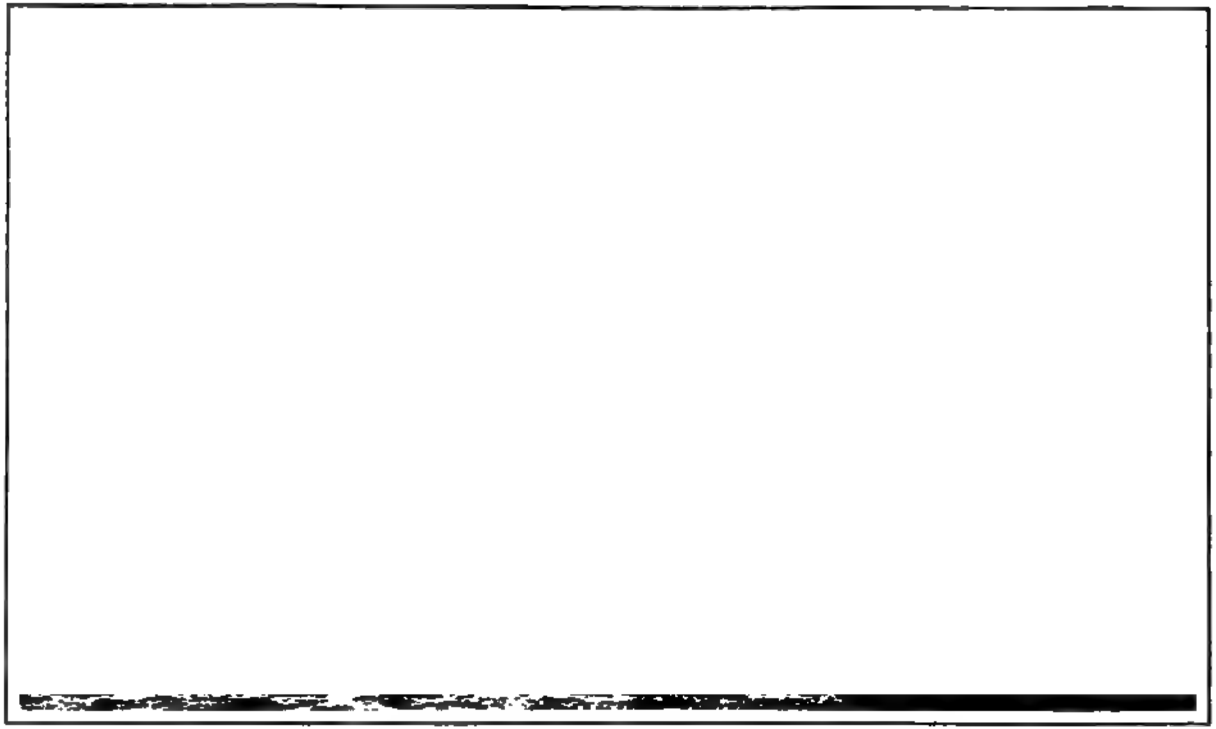
From a Photograph. By permission of the Cunard Steamship Co.

weighs about 100 tons, and there are about 2,000 feet of this, or 333 fathoms. The double bottom of the *Mauretania* averages in depth 5 to 6 feet, and she has five stokeholds containing twenty-three double-ended and two single-ended boilers; the coal bunkers are arranged along the ship's sides in such a manner as to be handy and as a protection to the hull in case of collision. Three hundred and twenty-four firemen and trimmers are engaged in three watches of four hours in the stokehold.

The striking illustration facing page 200 shows the stern of the *Mauretania* out of water, the photograph having been taken whilst the vessel was being built at Wallsend-on-Tyne by Messrs. Swan, Hunter and Wigham Richardson. It will be noticed that there are two propellers on either side of the rudder. The two outermost are driven by the high-pressure and the inside two by the low-pressure turbines. The two inner propellers are also used for going astern, and since the turbine can only turn in one direction these two are each fitted with a high-pressure turbine, and when the ship is steaming ahead these astern-turbines are simply revolving idly. When we examined the interior of a turbine on page 186, we noted that the steam is allowed to expand in stages therein. The turbines of the *Mauretania* are arranged with eight stages of steam expansion, while the blades vary in length from 2½ to 12 inches.

We would call attention once more to the modern custom introduced by Harland and Wolff of cutting a hole, or "port," in the deadwood of the ship. On referring to the illustration facing page 200, it will be seen that the *Mauretania* possesses this feature in a remarkable degree, so that the flow of water to the screws is very free indeed. It will be noticed also that the rudder is of the balanced type, so that part of

it projects forward of its axis, whilst the whole of it is some distance below the water-line. It will also be remarked that the two "wing," or outermost, propellers are placed a good deal forward of the two inner screws, the object aimed at being to give these forward screws plenty of clear water to work in without either pair of propellers having to revolve in water disturbed by the other pair. In examining this picture the reader will readily be able to obtain the scale by remembering that the draught up to the water-line shown is 37½ feet. The illustration facing this page shows the appearance these sister ships possess at the bows. The present photograph shows the *Lusitania* under way. The navigating bridge, which will be discerned at a great height, has been necessarily placed comparatively much nearer to the bows of the ship than is customary in many liners. Here the binnacle, the engine-room telegraph instruments, and other apparatus employed in the controlling of the ship, are stationed, whilst immediately abaft of this bridge, but in a connecting room, is the wheel-house. Into this small space is concentrated the exceptionally serious responsibility of ruling the ship, a responsibility which, though it now lasts but a short time, thanks to the shorter passages of the steamship, is far heavier than it was when steamships were less complicated and less huge. It is a responsibility which covers not merely the ship herself, the crew, the mails, and the passengers' lives, but sometimes a very precious cargo. Only whilst these pages are being written the *Mauretania* steamed into Liverpool a veritable treasure ship, far surpassing in this respect a whole fleet of some of those old Spanish treasure-frigates. Stored in the strong-rooms of the Cunarder were precious metals of the aggregate value of over a million pounds sterling, consisting of 6½ tons



THE "LUSITANIA."

From a Photograph. By permission of the Cunard Steamship Co.

of gold coin and 86 tons of bullion in the shape of 1,100 bars of silver. Add all this to the value of the ship, her furniture and her passengers' belongings, and we get something between three and four millions of money. The mere thought of it is enough to make Sir Henry Morgan and other buccaneers and pirates turn restlessly in their prison-graves.

Ever since they first came out the *Mauretania* and *Lusitania* have been improving on their speeds. Their most recent remarkable performances have been caused by important alterations to their propellers. These were preceded by experiments made by the *Mauretania's* builders with their specially constructed electrically-driven model launch. Since these two liners commenced running, over twenty-four different sets of three-bladed, and seventeen sets of four-bladed propellers have been tested, in addition to further frequent experiments with models of the three-bladed propellers originally supplied to the *Mauretania*. By modifying the bosses and the blades, and adopting four blades instead of three, a very extensive saving in horse-power was effected in experiments. Finally, the *Mauretania* was fitted with four-bladed propellers on the wing shafts, while three-bladed propellers were retained on the inside shafts. The result has been a substantial raising of her average speed, while the coal consumption has been about the same or rather less, but this latter is thought to be due probably to the improvements in stokehold organisation. Sir William H. White has expressed himself as of the opinion that the recently much increased speed of these two monsters is due much more to the greater knowledge of the turbines, as well as the better stokehold management, than to the propeller alterations. Up to May of the year 1908 the best average speed of the *Mauretania* on her westward trip was 24·86 knots,

but during the year 1909 it was raised to 26·6 knots. It was officially stated, on March 24th, 1910, that the *Lusitania* made a new record on her westward trip by steaming at 26·69 knots for a whole day, that is at the rate of 30·7 land miles. Leaving Queenstown on the Sunday, she had up till noon of the following Wednesday covered 2,022 knots, at an average of 25·97 sea miles. A fortnight previous to this the *Mauretania*, for the last part of her eastward voyage to Fishguard, steamed at an average speed of 27·47 knots per hour, or 31·59 land miles. The *Lusitania* is now fitted with the *Mauretania's* first propellers, and the chairman of the Cunard Company has remarked that he has been informed that the *Mauretania* would be glad to have them back again. The following tables will give some idea of the comparative passages which these ships have made. They are interesting as being reckoned not from Queenstown, but from Liverpool landing-stage and the Cunard pier, New York:—

		Outward Voyages		Days.	H.	M.
Lusitania	..	Quickest passage	..	5	7	0
Mauretania	..	Quickest passage	..	5	1	30
Lusitania	..	Longest passage	..	6	18	0
Mauretania	..	Longest passage	..	5	21	0
Lusitania	..	Average passage	..	5	21	35
Mauretania	..	Average passage	..	5	16	48

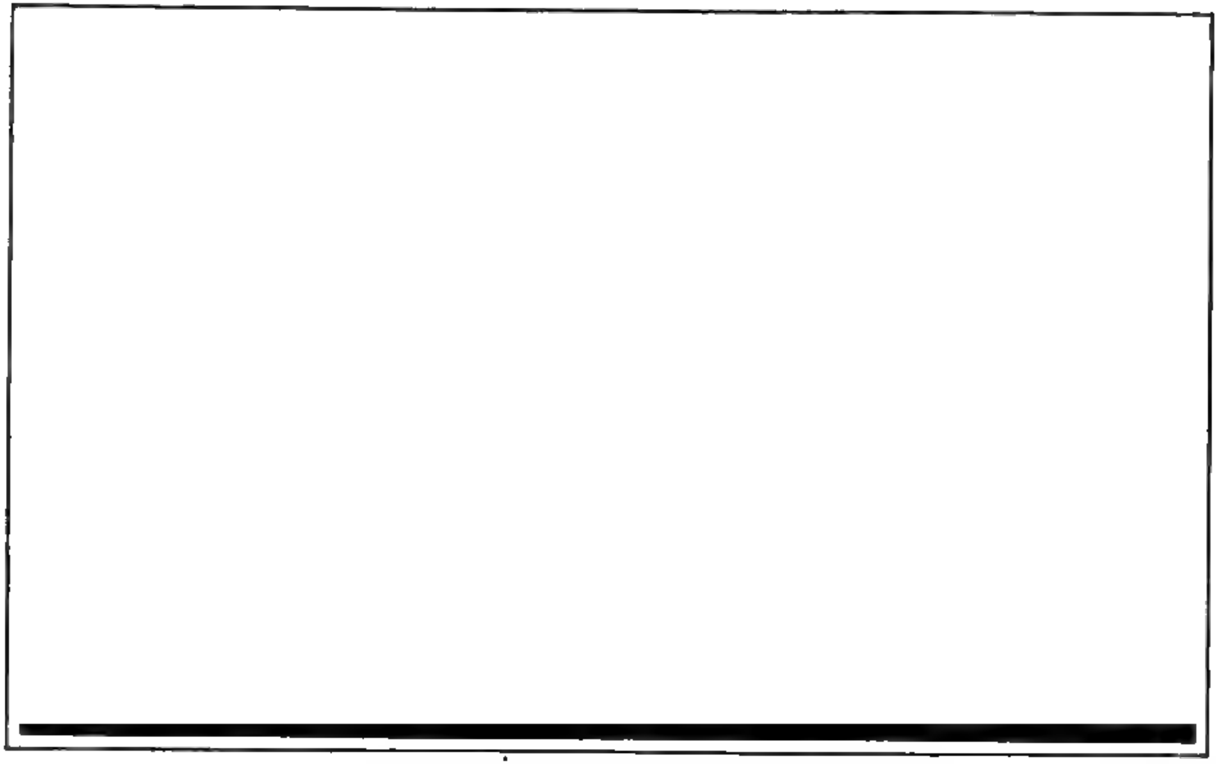
		Homeward Voyages.				
Lusitania	..	Quickest passage	..	5	15	30
Mauretania	..	Quickest passage	..	5	5	0
Lusitania	..	Longest passage	..	5	22	0
Mauretania	..	Longest passage	..	5	17	0
Lusitania	..	Average passage	..	5	19	22
Mauretania	..	Average passage	..	5	12	14

But in spite of their bold dimensions and their efforts to prove their superior prowess in contending with the mighty ocean, both the *Mauretania* and the *Lusitania* have shown that after all they are still yet ships, and are subject to those same laws which govern the rusty old tramp, the square-yarded sailing ship, and the massive modern liner. We may take but two recent instances, one as happening to each of these two great vessels during the winter of 1910. In the month of January, the *Lusitania* made the slowest passage in her history, having encountered adverse winds and mountainous waves ever since leaving Daunt's Rock. On Monday, the 10th of January, she ran into what was thought to be a tidal wave. Immediately an avalanche of water broke on the promenade deck. The officers on duty at the time calculated the liquid weight that came aboard at 2,000 tons, and 100 feet high. At the time of the occurrence the captain and the passengers were below at dinner, and it was fortunate that no one was on deck. The wave wrecked the pilot house, which is 84 feet above the water-line; four lifeboats were smashed, as well as eleven windows in the wheel-house. Companion ladders were carried away, while the captain's, officers' and their stewards' quarters below the bridge were so badly damaged that they could not be used. The chief officer was on the bridge at the time, and he found himself in water up to his armpits. The quartermaster was swept off his feet, and struck against the chart-room bulkhead, with the fragments of the steering wheel in his hands, and the chart-room was flooded everywhere with water. As if that were not bad enough, the masthead lights and sidelights were extinguished by the wave. Happily, the chief officer kept his head above all this excitement, and finding that the engine-

room telegraph gear was undamaged, signalled down to the engineer to reverse the turbines. The captain, who had only left the bridge a few minutes earlier, rushed back, and in less than half an hour the big ship was on her course again, heading for New York, where she arrived twenty-six hours late.

It was during the following month that the *Mauretania* also suffered her worst passage on record. The weather was so bad from the first that she was unable to land her pilot at Queenstown, who had to go all the way to New York. During the first day or two the sea became worse and worse. On the night of Sunday, February 20th, the *Mauretania* was in the thick of a heavy gale and meeting seas of rare magnitude. Some idea may be gathered of the conditions, when it is mentioned that the speed of this colossal liner had to be reduced to seven knots, and kept at that for the next five hours. It may be remembered that the Astronomer Royal reported that the wind-pressure at Greenwich that night showed a velocity of 100 miles an hour. When full steam was again resumed, the *Mauretania* received some punishing blows, and the upper works were subjected to a series of continuous batterings from heavy head seas. The glass of the bridge-house was shattered, several of the lifeboats were shifted, the water got below and flooded the forecastle, and finally an anchor, weighing 10,000 lbs., and 50 fathoms of cable were swept into the sea. Reading all this whilst having in mind the magnitude of these two steamships, truly we can say that the sea is no respecter of persons, nor even of the most marvellous products of naval architecture.

The four-masted steamship here illustrated is the White Star *Adriatic*, which was built in 1906. This mighty



THE "ADRIATIC."

From a Photograph By permission of Messrs Ismay Imrie & Co.

vessel is of 25,000 tons, and though smaller than the two Cunarders with which we have just dealt, is superior in size and speed to the White Star *Baltic*, and until the advent of the *Olympic* and *Titanic*, was the biggest production which the White Star Line has conceived. Like the *Baltic*, the second *Oceanic*, and the *Cedric*, this *Adriatic* follows out the modern White Star practice of giving mammoth size, moderate speed, and considerable luxury. She steams at 17½ knots with an indicated horse-power of 16,000. Unlike the more modern ships, the *Adriatic* is propelled not by triple or even quadruple screws, but by twin-screws, and is employed on the Southampton - Cherbourg - Queenstown - New York route. Although not provided with turbines, the *Adriatic* exhibits a minimum of vibration owing to the careful regard which is now paid to ensure the balancing of the moving parts of the reciprocating engine. She has two three-bladed screws, which are made of manganese bronze, driven by twin engines, and her dimensions are: length, 725·9 feet; beam, 77·6; depth, 54 feet. It will be seen, therefore, that the old ten-beams to length rule is yet again broken in the modern White Star leviathans.

In 1905, the German Hamburg-American Line became possessed of the *Amerika*, which with the length of 670½ feet, beam 74·6, and a tonnage of 22,225, and a moderate speed, makes her rather a rival of the White Star *Baltic* and *Adriatic*, than of the Cunard ships or the Norddeutscher Lloyd *Kaiser Wilhelm der Grosse* and *Kaiser Wilhelm II.*, and the Hamburg Company's own fast steamship, the *Deutschland*. Although sailing under a foreign flag, she is to all intents and purposes a British ship, for she was built at Harland and Wolff's famous Belfast yard, where the White Star ships have come into

being. Her speed is 18 knots, so that she is rather faster than the latest White Star ships, although inferior to the fastest contemporary liners. Carrying a total of 4,000 passengers and crew, the *Amerika* is one of the finest vessels, not merely in the German fleet, but in the whole world.

The *George Washington*, which is seen steaming ahead in the illustration herewith, was the first of the Norddeutscher Lloyd steamers to make a considerable advance on the 20,000 tons (registered) limit. In length, breadth and tonnage she was launched as the biggest of all German ships, and some of her details are not without interest. Her speed of 18½ knots is obtained by two engines with an indicated horse-power of 20,000, and her gross register is 26,000 tons. She is propelled by twin-screws, and was built of steel according to the highest German standards, with five steel decks extending from end to end, a double bottom, which is divided up into twenty-six water-tight compartments, while the ship herself is divided by thirteen transverse bulkheads which reach up to the upper deck, and sometimes to the upper saloon deck, and separate the vessel into fourteen water-tight compartments. A special feature was made in the bulkheads to render them of such a strength as to be able to resist the pressure of the water in the event of collision. The three upper decks seen in the photograph show the awning, the upper promenade, and the promenade-decks; while, as in the *Mauretania* and her sister, and in the *Adriatic*, electric lifts are installed for the convenience of the passengers wishing to pass from one deck to the other. The four pole-masts are of steel, and have between them no fewer than twenty-nine derricks. The *George Washington's* engines are of the quadruple-expansion type, with two sets of four cylinders, the propellers being two three-bladed, made of

THE "GEORGE WASHINGTON."

THE "BERLIN."

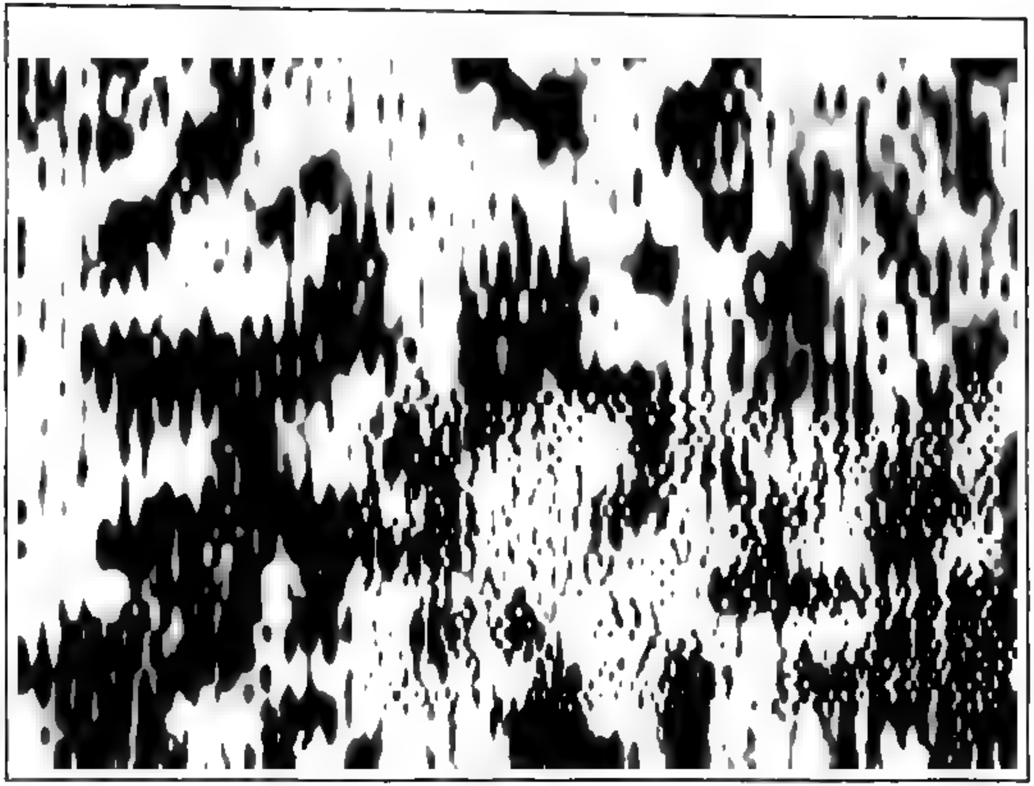
From Photographs. By permission of the Norddeutscher Lloyd Co., Bremen.

bronze. The difficulty with large reciprocating engines has always been to cause them to work without giving forth considerable vibration. But the careful arrangement of the cranks of the engine so as to balance each other tends to neutralise the vibration. It is easier to balance four cranks than three, and in this German ship the four-crank principle is followed. Steam is supplied by four single-ended and eight double-ended boilers, the Howden draught system being employed.

The *Berlin*, the other latest modern liner of the Norddeutscher Lloyd Line, will be seen in the next illustration. Unlike her sister, she has been given only two masts, and in another illustration, in a later chapter, we show this ship under construction. She was recently built at Bremen for the Mediterranean to New York service, and carries 3,680 persons, inclusive of crew. Like other modern German liners, this vessel is handsomely furnished, and the public rooms are all united in a deckhouse lighted by a large number of cupola-shaped skylights. She has a registered tonnage of 19,200 gross, and in the Norddeutscher fleet ranks next after the *Kaiser Wilhelm II.* She passed into the hands of her owners at the end of 1909.

Two interesting new ships were commissioned in 1909 by the White Star Line, for the Liverpool-Quebec service, named respectively the *Laurentic* and *Megantic*. An illustration, showing the former on the stocks at Harland and Wolff's yard, Belfast, is given opposite page 210. The *Laurentic* and *Megantic* are, as to hulls, sister ships, and each has a tonnage of 14,900, thus being among the largest steamers in the Canadian trade. But whilst the latter is a twin-screw ship propelled by reciprocating engines, the former has three screws and a combination of reciprocating engines and a

low-pressure turbine, being the first large passenger steamship to be designed with this ultra-modern method. Each of the "wing" propellers is driven by four-crank triple balanced engines, the central propeller, however, being driven by the turbine. The object aimed at by this novel hybrid method was to retain the advantages of the carefully balanced reciprocating engines, but at the same time to obtain the benefit of the further expansion of steam in a low-pressure turbine, without having to employ a turbine specially for going astern. The reciprocating engines of the *Laurentic* are adequate for manœuvring in and out of port, and for going astern, since they develop more than three-quarters of the total combined horse-power. This steamship, single-funnelled and two-masted, measures 565 feet in length, and 67 feet 4 inches in width, and besides having accommodation for 1,690 passengers, carries a large quantity of cargo. Like many other big steamships that we have noted in the course of our story, she has a double cellular-bottom which extends the whole length of the ship, being specially strengthened under the engines. Her nine bulkheads divide her up into ten watertight compartments. It will be noticed that the rudder has gone back to the ordinary type common before the introduction of the balance method. Notice, too, that the blades of the propeller are each bolted to the shaft, and that the latter terminates in a conical shape now so common on screw-ships. This is called the "boss," and was invented by Robert Griffiths in 1849. It was introduced in order to reduce the pressure of the water towards the centre. This method was first tried on a steamer in the following year at Bristol and afterwards on H.M.S. *Fairy*. By reason of its shape, it naturally causes less resistance through the water.



THE "LAURENTIC" ON THE STOCKS.
From a Photograph By permission of Messrs Harland & Wolff.

Whilst these lines are being written, there are building at Harland and Wolff's yard still another couple of ships for the White Star flag, which, if not in speed, will be the most wonderful, and certainly the largest ships in the world. After the *Baltics* and *Mauretanias* one feels inclined to ask in amazement: "What next, indeed?" They will measure 850 feet long, 90 feet broad, and be fitted with such luxuries as roller-skating rinks and other novelties. They will each possess a gross register of 45,000 tons. (By way of comparison we might remind the reader that the *Mauretania* has a gross register of 33,000 tons.) Named respectively the *Olympic* and *Titanic*, they will be propelled by three screws, and have a speed of 21 knots, so that besides being leviathans, they will also be greyhounds, and are destined for the Southampton-New York route. The first of these, the *Olympic*, will take the water in October, 1910, and some idea of her appearance may be gathered from the illustration which forms our frontispiece. Like the *Laurentic*, these ships will be fitted with a combination of the turbine and reciprocating engines, and will thus be the first ships running on the New York route to have this system. Their builders estimate that the displacement of each of these mighty creatures will be about 60,000 tons, which is about half as much again as that of the *Baltic*. Each ship will cost at least a million and a half of money, and it will be necessary for each of those harbours which they are to visit to be dredged to a depth of 35 feet. It is a complaint put forward by both ship-builders and owners of modern leviathans that the governing bodies of ports have not shown the same spirit of enterprise which the former have exhibited. To handicap the progress of shipping by hesitating to give the harbours a required depth, they say,

is neither fair nor conducive to the advance of the prosperity of the ports in question, and on the face of it, it would seem to be but reasonable that if the honour of receiving a mammoth liner means anything at all, it should be appreciated by responding in a practical manner. In New York Harbour this fact is already recognised, for dredging is being undertaken so as to provide a depth of 40 feet.

At the present moment the Cunard Company are also engaged in replenishing their fleet, consequent on the removal from service of the *Lucania*, the *Umbria*, the *Etruria*, and the *Slavonia*. An 18,000 ton steamship, to be called the *Franconia*, is being built by Messrs. Swan, Hunter and Wigham Richardson, Ltd., the firm which turned out the *Mauretania*, and will be ready some time in 1911. This latest addition will not, it is understood, be a "flyer," for her speed is believed to be less than 20 knots, and it is therefore probable that she is intended to replace the *Slavonia*. But it is supposed that another vessel is to be built presently to relieve the *Mauretania* and *Lusitania*, or to co-operate with them, and that her speed will be 28 knots, though it must not be forgotten that this ship will not be built with the help of Government money, but will be purely and solely a commercial transaction.

In the meantime German enterprise shows but little signs of lagging. The Hamburg-American Line are understood to have ordered from the Vulcan Yards at Hamburg a new passenger liner of more than 800 feet in length and a displacement of between 45,000 and 50,000 tons. Her speed is to be 21 knots. Herr Ballin a couple of years ago had a similar project in view, and entered into a contract with Harland and Wolff for building the largest ship in the world, to be called the *Europa*. But the condition of the Atlantic passenger

trade became unfavourable for the enterprise, and the contract was annulled. The contract now goes, not to Belfast, but to Hamburg, for the Belfast yard has no slip vacant for several months to come. It will mean, therefore, that this *Europa*, which is destined to excel the big Cunarders in size though not in speed, will be the largest undertaking that German ship-building yards have yet had to face, for the biggest merchant ship which up till now they have turned out is the *George Washington*, of 26,000 tons. Since the *Deutschland* lost the honour of holding the "blue ribbon," the Hamburg-American Line have not worried much about recapturing the first position in speed. Economy plus a first-class service would seem to be the modern combination of influence that is dominating the great steamship lines. Speed is a great deal, but it is not everything in a passenger steamship, and whether the limits have not already been surpassed, and the *Mauretania* and *Lusitania* with their high speeds and enormous cost of running will presently be regarded rather as belonging to the category of white elephants than of practical commercial steamships, time alone can show.

After all, the Atlantic and the other oceans were made by the Great Designer as barriers between separate continents, and although we speak of them casually as rather of the nature of a herring-pond, and build our big ships to act as ferries, yet are we not flying in the face of Nature, and asking for trouble? In the fight between Man and Nature, it is fairly plain on which side victory will eventually come, in spite of a series of clever dodges which throughout history man has conceived and put into practice for outwitting her. You can fool her very well in many ways for part of the time; but you cannot do this for ever in every sphere. When we read of fine,

handsome, well-found modern liners going astray in the broad ocean, or of excellent, capable little cross-channel steamships foundering between port and port, without any living witnesses to tell how it all happened, we have a reminder that the ways of man are clever beyond all words, but that Nature is cleverer still. What the future of the steamship will be no one can tell. Already ship-builders profess themselves capable of turning out a monster up to 1,000 feet in length. But whether this will come about depends on the courage of the great steamship lines, the state of the financial barometer, and any improvements and inventions which the marine engineer may introduce in the meantime. Perhaps the future rests not with the steam, but the gas engine: we cannot say. It is sufficient that we have endeavoured to show what a century and but little longer has done in that short time for the steamship. Sufficient for the century is the progress thereof.

CHAPTER VIII

SMALLER OCEAN CARRIERS AND CROSS-CHANNEL STEAMERS

Although it is true, as I have already pointed out, that the North Atlantic has been the cockpit wherein the great steamship competition has been fought out, yet it is not to that ocean alone that all the activity has been confined. Because of the limitations which the Suez Canal imposes it is not possible to build steamships for the Eastern routes of such enormous tonnage as are customary for the North American passages.

In the course of our story we have seen the beginnings of the principal steamship companies trading not merely to the west, but in many other spheres. In tracing the history of steamship companies as distinct from that of the steamship herself, we are immediately confronted with difficulties, for the company may be older than steamships of any sort; or, again, the company may be of comparatively modern origin, yet from the first possessed of the finest steamships, of a character surpassing their contemporaries. For instance, one of the very oldest lines is the Bibby Line to Rangoon. This was founded as far back as 1807, yet it was not until 1851 that it adopted steam. The White Star Line, as we have seen, was previously composed of sailing vessels, and its first steamship, the *Oceanic*, did not appear until 1870, but when she did make her appearance, she surpassed anything else afloat by her superior virtues. To take, therefore, a chronological survey of the establishment of the steamship organisations would

be to convey nothing satisfactory to us in our study of the evolution of the steamship, but nevertheless, we may pertinently set forth some of the more venerable but no less active steamship lines of the present day.

In addition to those already mentioned whose coming certainly was intimately connected with the evolution of the steamship, we might mention Messrs. George Thompson and Company's Aberdeen Line, which at one time was famous for its fine fleet of sailing ships. This line was established in 1824, the year of incorporation of the General Steam Navigation Co. Six years later the Harrison Line arose, though the Allan Line, which dates back to 1820, did not run its first steamer until 1854. The well-known Hull firm of Messrs. Thomas Wilson and Sons appeared in 1885, and the African Steamship Company three years earlier. In 1849 the City Line, now amalgamated with the Ellerman Line, was founded, as also were Messrs. Houlder Brothers. The Anchor Line came in 1852, and the Castle Mail Packets Company, which is now amalgamated with the Union Line to form the Union-Castle Line. The British East India Company dates from 1855, and the Donaldson Line a year earlier. The year 1856 saw the inauguration of Messrs. J. T. Rennie and Sons' Aberdeen Line to South Africa, and in 1866 the Booth Line was first started, whilst the Collins Line had been formed in 1850, the Inman Line the same year, the North German Lloyd in 1858, the Compagnie Transatlantique in 1861, the National Line in 1868, and the Guion Line (originally Williams and Guion) in 1866. Some of the last-mentioned are now extinct, and have been dealt with in another chapter. Within the last few months the P. and O. Company have absorbed the Lund Line, and the shipping interests of the late Sir Alfred Jones

THE "MOOLTAN."

From a Photograph. By permission of the Peninsular and Oriental Steam Navigation Co.

have been consolidated by Lord Pirrie, whose name is so well known by his close connection with the firm of Harland and Wolff. During 1910 another Atlantic service was inaugurated by the appearance of the Royal Line, which the Canadian Northern Railway Company is running between Bristol and the Dominion. Their two ships the *Royal Edward* and the *Royal George* were originally built under different names for an express service between Marseilles and Alexandria, but that venture was not found profitable. They have recently been modified to suit the North Atlantic route and are representative of the finest examples of the modern steamship, though not so large as the biggest liners. Propelled by turbines driving triple screws, they have all the luxury of the most up-to-date ships, with lifts, wireless telegraphy, special dining-room for children, cafés and many other up-to-date features. The Royal Line is thus another instance of a new steamship organisation stepping right into the front rank at the first effort. If it is alleged that some of the older lines engaged on the South Atlantic and Eastern routes have not shown that same progressive spirit which the North Atlantic companies have exhibited, at least recent ships have shown that everything is being done which can be expected, short of reaching the mammoth dimensions of the Atlantic liners. Passengers voyaging to Australia, India, South Africa, and South America, for example, realise that they are destined to remain at sea for a long period, and the question of the utmost speed is not of primary importance. Owing partly to the American spirit of speed and the much shorter distance which separates the two continents, the voyage between England and New York has become rather an elongated channel passage than a journey in which one settles oneself down for weeks, and the

incentives to make it shorter still are never for a moment wanting.

The recent additions to the P. and O. fleet are indicative that progress is not confined to any one route. A new epoch in the history of this company began when the first of their "M" class was added. Reckoning them historically from 1903 these are the *Moldavia, Marmora, Mongolia, Macedonia, Mooltan, Malwa, Mantua,* and the *Morea.* The smallest of these, the *Moldavia,* is of 9,500 tons; the largest are the last three mentioned, which are of 11,000 tons, and though wireless telegraphy has not played the same conspicuous part as on the Atlantic, yet this is now being installed in all the P. and O. mail steamers on the Bombay and Australian routes. Two new steamers, also of the "M" class, are being built, to be called respectively the *Medina* and the *Maloja,* which will be thus fitted. It is no doubt owing to the slowness with which Australia, India, and Ceylon have adopted land installations that a corresponding reluctance has been found in the case of the steamships to adopt what is so significant a feature of the modern steamship. The illustration facing page 216 shows one of this "M" class, the *Mooltan,* coming to her berth in the Tilbury Dock, whilst the opposite illustration will afford some idea of the starting platform in her engine room. Her measurements are: length 520·4 feet, beam 58·3 feet, and depth 33·2 feet; her tonnage is 9,621, with an indicated horse-power of 15,000. She was built in 1905 by Messrs. Caird and Company, of Greenock. It was owing to the increase in size of the new P. and O. ships that the comparatively recent transfer was made of the company's mail and passenger steamers from the Royal Albert Dock to Tilbury.

The Union-Castle fleet is composed partly of those ships

THE STARTING PLATFORM IN THE ENGINE ROOM OF THE "MOOLTAN."

From a Photograph. By permission of the Peninsular and Oriental Steam Navigation Co.

which belonged at the time of amalgamation to the old Castle Line, and partly of those which were of the Union Line. In addition to these, new steamships have been since brought out to swell the list. The depression in South Africa consequent on the Boer War necessitated a careful consideration before the addition of other mail steamers, but the *Balmoral Castle* (*see* opposite page 220), which was completed in 1910, and her sister the *Edinburgh Castle*, are the largest and most powerful vessels employed in the South African trade. This *Balmoral Castle* has a gross tonnage of about 18,000, with an indicated horse-power of 12,500, and is fitted with twin-screws. Fitted, of course, with water-tight bulkheads and cellular bottom, every modern improvement has been taken advantage of in her internal arrangement with regard to the service for which she was built. The *Balmoral Castle* has a deck space larger than that usually given in this line, the first and second class having practically the whole of the boat deck; whilst by joining the poop and promenade deck the third class have their deck space doubled. She is installed with the modern loud-speaking telephones between the bridge and engine-room and the extremities of the ship. Wireless telegraphy has not been installed, but a room has been specially built and equipped if it is decided hereafter to adopt this apparatus. On the fore-mast head a Morse signalling lamp has been placed for long distance signalling, and a semaphore after the Admiralty pattern on the bridge for short distance signalling. She is propelled by two sets of quadruple-expansion engines, and has ten boilers.

The White Star Line, in addition to their regular mail and passenger service across the North Atlantic, have three special freight and live-stock steamers—viz. the *Georgic*, of

10,077 tons, the *Cevic* of 8,301 tons, and the *Bovic* of 6,588 tons—all of these having twin-screws. Besides these they possess four ships engaged on the New Zealand route, five on the Australian trade, besides two smaller ships for freight.

We have already mentioned the *Ivernia* and *Saxonia* as belonging to the intermediate, economical types which the Cunard Company own in addition to their bigger liners. They also carry on a Mediterranean service from New York to Gibraltar, the Italian and Adriatic ports, to Algiers and Alexandria. The North German Lloyd Company also own a number of smaller steamships employed in intermediate service to ports other than those served by their fast liners, the largest being of about 6,000 tons.

The American Line, which was formerly the old Inman organisation, own besides the *Philadelphia*, already discussed, the *New York*, the *St. Louis*, and *St. Paul*, but the last two, each being only 11,629 tons, are the largest of their small fleet. Besides the Anchor and the Allan Lines and the new Royal Line the Canadian Pacific Railway now maintains a long connection by steamship and railway from Liverpool right away to Hong Kong through Canada. The *Empress of Britain*, with her quadruple-expansion engines and twin-screws, is one of the finest steamships on the Canadian route.

We could continue to deal singly with all the steamship lines which have now sprung into existence, with the fine ships of the Atlantic Transport Line, whose *Minnehaha*, in the spring of 1910, had the misfortune to run on to the Scillies during her voyage from America to this country. We might instance the Holt Line, the Nelson Line, and other enterprising organisations, but such matter would hardly come within the scope of our subject, which shows the manner in which the

THE "BALMORAL CASTLE."

From a Photograph By permission of the Union-Castle Mail Steamship Co.

steamship has developed into so useful an institution. Since we have now been able to witness the manner in which the steamship has been adapted for service across the deep, wide ocean, let us, before we close this chapter, take a glance at the way in which she has also become so indispensable for those shorter but no less important cross-channel passages.

At an earlier stage we saw that the cross-channel steamship service owed its inauguration almost exclusively to that shrewd Scotsman, Napier, who, after devoting a great amount of patient study to the subject, evolved the *Rob Roy*. But we must not omit to give credit also to others whose work in this connection has been of such historic importance. From about the second decade of the eighteenth century there had been a service between Holyhead and Dublin, carried on by means of sailing packets, as there was, indeed, between Scotland and Ireland, as well as England and the Continent. Then had come the first steam service when the *Talbot*, of 156 tons, built in 1818 at Port Glasgow, for David Napier, began running in the following year between Holyhead and Dublin. In 1819, also, was inaugurated the Liverpool and Dublin service, and in 1823 one of the oldest steamship companies still in existence, the Dublin Steam Packet Company, was formed. It must be recollected that the journey between London and Dublin was a long and tedious one, for there was no railway, and considerable sums of money were expended in order to improve the road between Holyhead and the English capital. The sailing packets took on the average about twenty hours to cross the Irish Channel. The *Royal William*, already alluded to when we discussed the first Atlantic steamers, was one of the early steamships of this City of Dublin fleet. In 1836, when George Stephenson proposed the construction

of the Chester and Holyhead Railway, he intended that the company should also provide ships between the latter port and Ireland, but the various steamship companies opposed this until 1848. The London to Liverpool railway was opened in 1838, and so, since the Liverpool to Dublin route was the quickest way to get from London to Ireland, Holyhead was given the cold shoulder for the next ten years. But when the continuous railway was opened between London and Holyhead, the popularity of the Welsh port returned, and the directors and principal shareholders of the Chester and Holyhead Company, who had formed themselves into a small independent company, ordered four new vessels, the *Cambria*, the *Anglia*, the *Hibernia*, and the *Scotia*. Of these the first is illustrated herewith. These ships were 207 feet long, 26 feet wide, and 14 feet deep, with a draught of 8 feet 10 inches. They had a gross tonnage of 589, carried 585 passengers, and possessed the remarkable speed of 14 knots. Instead of the slow passages of the old sailing packets these four ships lowered the average voyage to 8 hours 34 minutes. In 1859 this Chester-Holyhead railway was amalgamated with the London and North Western Railway, and in 1868 the latter introduced a new type of craft, with the same speed as before, but of 700 tons. Both a day and a night service were presently instituted, and this service has continued to be one of the most efficient and the fastest of all the cross-channel ferries from this country. Of four new vessels which were built for the Holyhead-Kingstown service in 1860 we may mention the *Leinster*. She was a large vessel for those times, with a displacement of 2,000 tons, and constructed of iron. The illustration facing this page shows a capital model of her engines, which were of the oscillating type, and since we have previously described this kind

THE "CAMBRIA" (1848).

From a Painting. By permission of the London & North Western Railway.

ENGINES OF THE "LEINSTER" (1860).

From the Model in the Victoria and Albert Museum.

it is hardly necessary to deal with them now, further than to remark that they gave the ship a speed of nearly 18 knots.

Coming now further south, it will be remembered that Napier's *Rob Roy*, which had first plied between Greenock and Belfast in 1818, was in the following year transferred to the Dover and Calais route, and was thus the first regular steamship to open the mail and passenger service between these ports. This was followed for a long time by other steam "ferries," some of which were Government mail packets, and others were privately owned. The General Steam Navigation Company, which had been formed in 1820, and commenced its steam coastal trade, was not long before it had inaugurated a service between London and Hamburg, and by 1847 it had steamships running between London and the following ports:—Hamburg, Rotterdam, Ostend, Leith, Calais, Havre, as well as from Brighton to Dieppe, and Dover to Boulogne. These were all paddle-steamers until the screw was introduced in 1854. In April of 1844 their paddle-steamer *Menai* was advertised to leave Shoreham Harbour, calling at Brighton Chain Pier—or rather Brighthelmstone, as it was then still known—and thence proceeding to Dieppe. She was thus the first channel steamer to run between these places.

It was not until the old stage-coach had given way to the railroad that the numbers of travellers between England and the Continent increased. By June of 1843 the South Eastern Railway had reached Folkestone, and in February of the following year it had also joined Dover. The London, Chatham, and Dover Line was of later date, and did not reach Dover until 1860, where they were able to put to the best use their capable fleet of passenger boats which steamed to Calais. But in 1845 the South Eastern Railway had, like the Chester and

Holyhead Line, formed themselves into a separate company, to run a line of steam packets, owing to the fact that the successors to the *Rob Roy* were deemed unsatisfactory, and endless objections were made by the complaining passengers who reluctantly crossed the choppy waters of the English Channel. Previous to this date the South Eastern Railway were wont to hire steamships to carry their passengers between England and the Continent to Boulogne, Calais, and Ostend. When their line had joined up Dover they started running from there to Calais with their own boats in two hours, twenty-eight minutes, calling at Folkestone on the way for twenty-eight minutes. The first of these steamboats were the *Princess Maud* and the *Princess Mary.* The run from Dover to Ostend took four and a half hours.

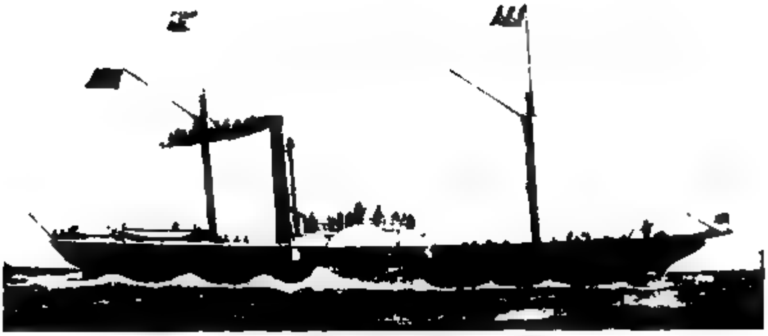
In 1848 the Admiralty, which had been responsible for the steam mail packets service (as also we have seen earlier in this book they had charge of the transatlantic mails), handed over their charge to the Post Office. But neither of these Governmental branches was able to make a success of this, and after a time the Post Office withdrew their mail packets and in 1854 put the carrying out to contract. A Mr. Churchyard was accepted as the contractor, and his agreement continued until 1862. It will be recollected that two years previous to the latter date the London, Chatham and Dover Company had connected their line to Dover, and they obtained the contract in succession to Churchyard for carrying the mails from Dover to Calais. At the same time the South Eastern Railway Company withdrew their steamboat service to Folkestone. It should be mentioned that the General Steam Navigation Company had also withdrawn from this route owing to the competition on the part of the railway companies, who

were in a superior position by being able to run their passengers on both their own railways and their own steamboats.

The general character of these early cross-channel steamcraft was very similar to that of the *Cambria*. Some of the steamboats employed on this Dover-Calais route have been marked by the possession of exceptional features. It was in 1875 that the *Bessemer* was designed with the object of making the dreaded passage across the Straits of Dover less disagreeable and free from the infliction of sea-sickness. To this end she was given a unique apparatus which was to swing with the motion of the vessel, and in such a manner that the passengers would always be kept on a level, however much the ship might roll. She was built double-ended, so that she would not have to be turned round when she reached the French port. But emphatically she resulted in a complete failure, for not only was this ingenious deck found to be unworkable, and had to be fixed, but the *Bessemer* collided with Calais Pier, and succeeded in knocking away about fifty yards thereof.

Another ingenious vessel on this service was the *Castalia*. She was a twin-ship composed of a couple of hulls. Those who crossed in her about the year 1876 found her very comfortable, and she was so steady that comparatively few of her passengers were sea-sick, but her drawback was that she was not fast. The genesis of this double-hulled ship was in order to obtain greater steadiness, and the experiment was first tried by fastening two Woolwich steamers together, having first removed the inside paddle-wheels. Following up this, the same principle was exemplified in a ship called the *Express*, which had been constructed for a firm that became financially embarrassed, and she was accordingly taken over instead by the owners of the *Castalia*, and became the famous *Calais-Douvres*, which

most of my readers will well remember. She was certainly a fast ship, but her life was not devoid of adventures. In May, 1878, she collided with Dover Pier through her steering-gear going wrong, her main engines having previously broken down. She was subsequently repaired and did well until 1887, when, worn out by active service, she was withdrawn, having proved an expensive boat to run, and obtained an unenviable reputation for a large coal consumption. The *Castalia* was withdrawn in 1878, and became a floating small-pox hospital on the Thames, where she remained for about twenty years, and was finally towed therefrom to Dordrecht by one of that fleet of Dutch tugs which we shall mention in a later chapter as being famous for the towage of big docks. In the course of time new and improved Channel steamers continued to be put on this Dover-Calais route, and in 1899 an amalgamation of interests owned by the South Eastern and the London, Chatham and Dover Railways took place, so that now the two fleets are under one management. Within recent years they have shown a very enterprising spirit by leading the way in placing turbine steamers on their route, and the illustration on the opposite page shows their turbine steamer *Empress* clearing out of Dover Harbour. In general character we may take the appearance of this vessel as typical of the more modern cross-channel steamers which now ply also on other routes owned by the various railway companies. The fine service of steamboats, for instance, possessed by the Great Western, Great Eastern, the Midland, the London and North Western, the Great Central, and the London and South Western consists rather of miniature liners of a very up-to-date type. Not merely wireless telegraphy and turbines have been introduced into the cross-channel steamers, but every con-



THE "ATALANTA" (1841).
From a Painting. By permission of the London and South Western Railway Co.

THE "LYONS" (1856).
From the Model in the Victoria and Albert Museum

THE "EMPRESS" LEAVING DOVER HARBOUR.
From a Photograph. By permission of the South Eastern and Chatham Railway Co

ceivable regard for the comfort of the passengers has been taken commensurate with the size of the ships, and the special work which they are called upon to perform.

We have addressed ourselves especially to the services between Dover and Calais and between Holyhead and Dublin, for, owing to their geographical character, these two are naturally the most important and the most historic. The custom of railways being owners of steamships has continued, the chief exception being the Great Northern Railway. The Newhaven to Dieppe route is of comparatively modern origin, and it was not until 1847 that the London to Newhaven line was completed. During the following year there were three steamers running to Dieppe from this port, but at first the London, Brighton and South Coast Railway was thwarted owing to legal difficulties, and properly their service dates from 1856, for at one time they were compelled to run a service under different ownership from their own. The model shown opposite page 226 shows the packet steamer *Lyons*, which was built in 1856 for the Newhaven-Dieppe service. She was a paddle-boat of 815 tons displacement.

Between England and the Channel Isles connection in the pre-steamship days was kept up by sailing cutters. After that the Admiralty conveyed the mails from Weymouth to Jersey and Guernsey by ships of the Royal Navy, and one of these—the *Dasher*—was until recent years employed in watching the oyster fisheries off Jersey. But in 1835 a steam packet service was started from Southampton to Havre, twice a week, and between the Hampshire port and the Channel Islands, which was owned by the South of England Steam Navigation Company, while a rival came forward in the British and Foreign Steam Navigation Company, which ran to the

Channel Isles. One of the earliest steamers belonging to the former company was the *Atalanta*, of which we give an illustration opposite page 226. She was afterwards lengthened, and as thus altered she appears in our illustration. Her days were ended as a coal hulk in Jersey.

From 1838 to 1845 the mail service between England and the Channel Isles was carried on from Weymouth, but in the latter year this service was transferred to the South Western Steam Packet Company, and remained exclusively with the Southampton steamers until 1899, when the joint running of the Channel Islands service by the steamers of the London and South Western from Southampton, and of the Great Western Railway from Weymouth, once more caused mails also to be carried from Weymouth. It was in the year 1860 that the South Western Railway, following the prevailing custom, took over their fleet from the South Western Steam Packet Company, and under the railway ownership this service has continued ever since. The origin of the Weymouth service was on this wise. An opposition company had been floated by the Channel Islands merchants under the title of the Weymouth and Channel Islands Steam Packet Company, and this continued until 1888, when the service was taken up by the Great Western Railway Company. For a time the keenest competition between the two railway companies as steamship owners continued, but after eleven years an amicable arrangement was come to whereby they agreed to work a joint service, which agreement is still in force. To-day, notwithstanding the losses which have been sustained by sad disasters involving loss of life, notably the memorable instance of the *Stella*, which foundered on the Casquets in March, 1899, this fleet is able to keep up an uninterrupted service carrying passengers, mails,

and freight, whilst during the summer season extra cargo steamers have to be put on for the conveyance of the big potato trade, fruit and flowers. These vessels, by reason of their route, cannot be expected always to avoid accidents. Those who know the treacherous character of the Channel Islands coast-line, and the continuous stream of traffic which is going up and down the English Channel, will readily appreciate what it means to take a small steamship from port to port in thick weather. It was only in April of 1910 that one of the London and South Western Railway boats, the *Laura*, while on her way from Southampton to Cherbourg, collided when about twenty miles south of the Needles, with a Norwegian sailing vessel named the *Sophie*, bound up channel from South America to Hamburg. Here again the wireless telegraph gear came in useful, for it chanced that the Royal Mail Liner *Asturias* was in the vicinity, and she at once telegraphed for assistance. These Channel Islands steamers all carry sufficient coal for the voyage there and back, with an additional amount adequate for all ordinary contingencies. From Southampton also the same owners carry on a steamboat service to Havre, Cherbourg, Honfleur, Roscoff, and St. Malo; while from Jersey to St. Malo and from Jersey to Granville two twin-screw steamers are employed.

Between Harwich and the Hook of Holland, the Great Eastern Railway keep up an important steamship connection, and employ in their ships not merely wireless telegraphy, but the submarine signalling which is mentioned as being a characteristic of the modern Atlantic liner. Their turbine steamer, the *St. Petersburg*—a sister ship to the same company's *Munich* and *Copenhagen*—which was only put into active service in 1910, began a steamship connection that is carried on

entirely by turbine craft. It is, indeed, owing to the advent of the turbine that the notable improvements in our cross-channel steamers have been made within the last few years. Not only has this system obtained for the ships a greater popularity because of the absence of vibration, but it has also enabled the owners to avail themselves of the greater accommodation for cargo and passengers, as well as giving greater speed to the ships under economical conditions of working.

One of the most notable cross-channel steamers is the Isle of Man Steam Packet Company's *Ben-my-Chree,* which can do 25 knots per hour and carry 2,500 passengers. On this route the turbine has very decidedly justified itself also. A breakdown causing the disablement of the turbine steamer is as yet unknown, and it is worth noting that from the now celebrated Channel steamer *Queen,* a turbine steamer of only 8,000 horse-power, which was ordered only as recently as the year 1900, to the *Mauretania,* with her 70,000 horse-power, is a step that shows how thoroughly satisfactory the turbine has proved itself in so short a space of time. In the case of a liner a breakdown is a serious enough item, but in the case of a channel steamer it is an occurrence of sufficiently grave a nature as to be guarded against with every precaution. The chances of a shaft breaking in the case of a turbine steamer are very remote, and will probably continue to be so, with the steady nature of the working of the turbine, the worst likely accident being the breaking of one of the many blades.

Moreover, the turbine has proved that it gives increased reliability to the steamship, which, in the case of the short cross-channel voyages, is a matter that cannot lightly be regarded. In the case of the *Ben-my-Chree* just mentioned, the mean time in performing the distance from Liverpool

Bar lightship to Douglas Head differed only by a minute in one season from that of the previous year, a fact that is highly significant. It is the time that is wasted in manœuvring to get alongside the quay and clearing away that detracts from the smartness of the voyage, although in this connection it may be stated that bow rudders are in use in certain cross-channel craft in order to enable this manœuvre to be accomplished with greater celerity.

It is curious how the channel service of a steamship line presents difficulties and problems of its own no less than those demanded by the ownership of ocean-going steamships. Obviously the short-voyage ship is limited as to size. What she has to accomplish must be done quickly. Not only must she get out of one harbour and into the other with the greatest economy of time, but she must get up her full speed at once. Then, again, owing to the demands of the passengers for special comfort a great strain is put on the patience of those responsible, as well as on the designer of the ship. Cross-channel steamers which have a fairly long night passage require a good deal of their limited space to be usurped by extra stateroom accommodation, and the modern demand for single-berthed cabins means rather more than the average passenger realises. The figures work out something as follows in the case of a four-berthed room the measurement of the space occupied comes to about seven-eighths of a ton per passenger. In the single-berthed cabin it becomes nearly two and a quarter tons per passenger. All this means that the ship has less available space for earning her living, since fewer passengers and less cargo can thus be carried.

Again, the passenger is spoiled nowadays. If a line has turbines and wireless telegraphy, submarine bells, the latest

conceivable luxury, speed and other virtues, he is sufficiently well informed to appreciate these things to the disadvantage of another service, scarcely less efficient, but perhaps a little less advanced in accordance with the very latest inventions and improvements. An old ship that has done years of good service and earned a reputation for punctuality and reliability has to be scrapped before her time just because a rival service has held out the tempting bait of the latest steamship features. On the other hand, there was room for an approach to be made towards more satisfactory conditions. The short crossings on some of the cross-channel steamers were in the past no unmixed joy. The bad sea-boats which some of these proved themselves to be, driven at a speed that made them vibrate from stem to stern, wet and generally uncomfortable, badly ventilated and equally inefficiently lighted, they certainly belonged to the days that are past. What the future has in store this deponent knoweth not; but if the internal combustion engine should ever become sufficiently popular for big ships, certainly in no service is it likely to be more suitable than in the cross-channel voyages, where speed is a vital consideration. But economy is equally to be taken into account, if steamers are still to be regarded as commercial, dividend-earning concerns, and not exclusively as objects for the exercise of sentiment. We have, owing to the influences at work everywhere, come to regard the virtue of speed as excelling everything else. Whether this is deserving of all-powerful merit, or whether in the future there may be a reaction and a desire to "go slow," time alone can tell. Perhaps such a condition might lead to an increased tranquillity of life as a whole, but it would also put a brake on progress generally, and on the steamship in particular.

CHAPTER IX

STEAMSHIPS FOR SPECIAL PURPOSES

We have been enabled to gain some idea by now both of the nature and the historical evolution of the steamship liner. But not all steamships are liners, any more than all cattle are race-horses. Steamship is a word which covers a multitude of varying craft and embraces a large family of different natured children. Some of them go out into the world far beyond the horizon and vanish until a few weeks or months later they come returning homewards proud of their achievements as the safe carriers of mails and passengers. But there are other members of the same family whose duty keeps them close to the home where they first saw the light; who rarely venture out of sight of land. There are others who, though they never carry any passengers but their crew, nor an ounce of cargo, are yet as useful to the human race as those great speed-makers which go rushing through night and day across the ocean. Some of these steamships used for special purposes have a character of their own no less distinctive than their more elegant sisters, and the mere fact that they are not so violently advertised, or so prominently pushed before the eyes of the average citizen, detracts nothing from their interesting virtues. Nor, again, do we wish to give the impression that this large class of special steamships is in any way entirely confined to coasting or inland voyages. The steamship nowadays, both large and small, goes everywhere, and is ready to do almost anything, and one of the most interesting of all

mechanically-propelled craft is the tug-boat; which it is quite possible the landsman, promenading his floating hotel, may have barely deigned to cast his eyes upon as his big steel home is being drawn out from the quay, or landing-stage, and swung round on her way to the other side of the world. How frequently indispensable is the tug to the big steamship, both when entering and leaving the comparatively narrow harbours! You see her at Southampton, for instance, pulling the great steel hull away from the quay; you see her at Liverpool hauling ahead to get the mighty, towering bows of the liner clear of the landing-stage out into the river. You see them in New York when the mammoth comes to enter the narrow opening alongside the pier, pressing their noses on to the mammoth's stern and compelling her giant dimensions to move round. Or, again, you see the tug towing her overgrown sister through the dock at the end of her voyage, coming slowly in as if she had captured one mightier than herself, and was proudly conscious of her performance. Yet it is not only the big steamships, but those beautiful modern steel sailing ships which have to employ her help. You meet them down Channel somewhere with perhaps only staysails and jigger set and a powerful tug ahead at the end of a strong tow-rope. In a day or so they will have parted company. The tug will return whence she set out; the bigger ship will spread her canvas and begin her many-monthed voyage.

It is possible that if you were not a sailorman, and your eyes chanced to fall upon such a ship as that illustrated opposite this page, whether in harbour or at sea, you might feel no more interest in her than in any other craft. And yet this is a little vessel which can go anywhere and tow almost anything from a great floating dock to a disabled liner. Her name is

THE OCEAN TUG "BLACKCOCK."

From a Photograph. By permission of the Liverpool Screw Towing & Lighterage Co.

THE PASSENGER TENDER "SIR FRANCIS DRAKE."

From a Photograph. By permission of the Great Western Railway Co.

the *Blackcock*, and she is one of the famous, powerful tugs owned by the Liverpool Screw Towing and Lighterage Company. Captain G. B. Girard, who commands the *Blackcock*, has been aptly termed the "Grand Old Man" of deep-sea towing, and during the last quarter of a century has covered 200,000 miles over the seas at this work. Quite recently he took the *Blackcock* to Fayal in mid-Atlantic to fetch over to Oporto a dismasted Portuguese barque. In spite of stiff breezes and heavy cross seas, the *Blackcock* and her tow made an average of 160 miles per day. It was this same tug which set up an interesting record some years ago by steaming 2,600 miles from Barbados to Fayal without having to stop for coal anywhere. She was towing a 2,000-ton German ship, named the *Ostara*, from Barbados to Hamburg, a distance of 5,000 miles altogether. In 1894, the *Gamecock*, a sister of this tug, towed a disabled steamer from Port Said to Liverpool, a distance of 3,300 miles, in twenty-seven days. The *Blackcock* took an important part in towing from Fayal to Liverpool the Cunard liner *Etruria*, which had been disabled, and caused the greatest anxiety in consequence of her being lost sight of for so long a period with hundreds of passengers aboard at the time. This towing voyage represented a distance of a couple of thousand miles, and there are many other equally wonderful incidents connected with these well-known "Cock" tugs. If the reader will bear in mind what we said some time back with reference to the origin of the bridge deck, he will be able to see the point well-illustrated in the illustration before us. The bridge deck and its sides are joined to the ship's hull in such a way that in the case of the tug being attacked by a cross-sea she is not likely to founder through the water getting down below to the engines, as in the sad

incident that we chronicled at an earlier stage. These tug-boats are necessarily exceptionally powerful, the *Blackcock* having over 1,000 horse-power.

But it is the Dutch, for some reason or other, who have specialised more than any other country in the towing industry, and they own the largest and finest tugs in the world. The reason for this national development I attribute partly to the nature of the coastline between Germany and France, with its series of nasty sandbanks and shoals always ready to pick a ship up; partly, also, to the numerous straightways with frequently a foul wind. In either case there is plenty of opportunity for the tug to go out and earn a living.

The finest fleet of ocean-going tugs is owned by Messrs. L. Smit and Company, of Rotterdam. Besides about a score of river and harbour craft, they have no fewer than ten bold ocean-tugs, which by reason of their high power and large bunker capacity are enabled to undertake towages to almost any part of the world. When the *Mauretania* left the Tyne for her trial trip this company's tugs, the *Ocean* and the *Poolzee,* had her in tow at the bows. Tugs of this line have also accomplished such interesting long voyages as towing floating dry-docks from the Tyne to Trinidad; an obsolete Spanish warship from Ferrol to Swinemünde; the s.s. *Kronprinzessin Victoria* from Las Palmas to Antwerp, after the liner had lost her propeller. When the old Inman liner *City of Rome* was put aside, she was towed by the tug *Zwarte Zee* from Greenock round to the Weser. The illustration facing this page shows the tugs *Roode Zee* and the *Zwarte Zee* taking in tow an enormous floating dock, capable of holding vessels up to 7,000 tons, from Wallsend on Tyne to Callao (Peru). To tow so unwieldy a thing as this for any distance at all is

THE 7,000 TON FLOATING DRY-DOCK UNDER TOW BY THE "ROODE ZEE" AND "ZWARTE ZEE."

From a Photograph. By permission of Messrs L. Smit & Co., Rotterdam.

a pretty severe tax on a tug; but to take it all the way to Peru on the west coast of South America is about the utmost test which the most severe critic could ever impose. The distance is 10,260 nautical miles. One of the largest and most modern of this line's tugs is the *Zwarte Zee*, which was launched in 1906. She resembles very closely the *Roode Zee*, seen in the foreground of the accompanying picture, and measures 164 feet long, 30 feet wide, 18 feet deep, and has the extraordinary high horse-power (indicated) of 1,500. It will be noticed that, like the *Blackcock*, she is well protected by her bridge deck amidships.

The sturdy little vessel illustrated opposite page 238 shows the salvage tug *Admiral de Ruyter*. She is owned by the Ymuiden Tug Company, Amsterdam, and is stationed at Ymuiden in readiness to render assistance to vessels in distress off the treacherous Dutch coast. She is capable of facing any weather, and her high bows and bold sheer enable her to keep fairly dry in even a pretty bad sea. An interesting comparison will be seen between this and the *Edmund Moran*. This represents a typical New York harbour and river tug. No one who has ever come into the American sea-port can have failed to have been struck instantly by the numbers of fussy little tug-boats of a peculiar type that come running up and down the Hudson and across from the New Jersey shore to the great city. Their prominent features include a good deal of sheer, an exaggerated bridge deck with wheel-house in front, at the top of which is usually a golden spread-eagle. In the winter-time, when thick ice-floes obstruct the Hudson and the bitter cold penetrates into the little wheel-house, there are more comfortable though less exciting avocations than those enjoyed by the commanders of these busy steam

craft, which now carry on their work in such numbers where little more than a century ago Fulton's *Clermont* was scorned and ridiculed by those who never thought that the river and harbour would ever see such steam-shipping.

But the tug-boat has in some cases been enlarged, and super-imposed by a promenade deck, and even given a saloon so as to become a passenger tender. The illustration opposite page 284, for instance, shows this evolution. This is the *Sir Francis Drake*, one of the passenger tenders owned by the Great Western Railway Company, and, since the opening of Fishguard Harbour for the calling of Atlantic liners, this vessel has been employed for landing the *Mauretania's* and other great ships' passengers without wasting time. The liner comes into harbour from America, lets go her anchor, and immediately after there come alongside her three of these tenders. One takes the mails as they are shot on to her deck, another receives the baggage, while the third is used for passengers; this third tender is also the last to leave the liner, so that when the passengers get ashore they find their baggage already awaiting them at the Customs platform. In the olden days the tug was a wheezy old lady lacking the smallest attempt at smartness, and exceedingly slow. Her hull was of wood and clinker built, her paddle-wheels gave to her a very moderate speed, and her accommodation was chiefly non-existent. But to-day, as the *Sir Francis Drake* shows, she has developed in some cases into practically an Atlantic liner in miniature.

But although the screw-propeller has ousted the paddle-wheel in very many instances, yet this has been by no means universal. The advantage which the older method possesses is that it can work in less water than the screw needs for its

THE SALVAGE TUG "ADMIRAL DE RUYTER."

From a Photograph. By permission of the Ymuiden Tug Co., Amsterdam.

THE NEW YORK HARBOUR AND RIVER TUG BOAT "EDMUND MORAN."

revolutions. In certain harbours, for instance, and shallow rivers—especially in those extreme cases where it is weedy—the paddle-wheel steamer is still pursuing its useful work. It is therefore not unnatural that the tug should in many cases be paddle-driven. The illustration facing page 240 shows one of these paddle-tugs of a fairly modern date. She is owned by the British Admiralty. The *Dromedary*, as she is called, is well known among the Portsmouth craft, and just as the tug is employed for helping liners out of port, so the Admiralty use the *Dromedary* for assisting such leviathans as the modern *Dreadnoughts* out of Portsmouth harbour, and rendering assistance in berthing in a harbour where the tides are very strong and the water is considerably crowded.

We referred in a preceding chapter to the serious difficulty which, owing to the gradual increase of the modern steamships, is felt in certain ports. New York harbour had to be dredged before it could accommodate the *Mauretania* and *Lusitania* with safety. Liverpool's depth of water is such that the two Cunarders can only enter during twelve hours out of the twenty-four. Fishguard has had to be dredged, whilst Southampton has been, and will need it again. In a smaller degree most ports need constant dredging, otherwise local conditions combine to silt up the navigation channel. Now all this is carried out by specially designed steamships, which, like other vessels, have gradually been increasing to enormous sizes. We might divide dredgers into two classes—the "bucket" dredger, and the "suction" dredger. The illustration facing page 240 gives an excellent idea of the former. This is the *Peluse*, the largest sea-going bucket-dredger in the world. She was built by Messrs. Lobnitz and Company, Limited, of Renfrew, for employment on the Suez Canal.

There is nothing in the least beautiful about this type of steamship. Ugly to look upon, splashed all over with mud and sand, covered with machinery and unsightly erections, they are sisters of toil to the ships of beauty. They "bring up" in a harbour or channel, and set their series of buckets dredging away to increase the depth. These buckets are readily seen coming down from a height in the centre of the ship. They are revolved by an endless chain, and the ship is cut open longitudinally to allow them to work.

It will be noticed that since the rudder, if placed in its accustomed place in the centre line of the hull, would be in the way, it has been duplicated and placed on either side of the stern. After the dredger has taken aboard her full cargo of mud from the sea-bottom she proceeds to the deep sea, and there discharges her contents through doors placed in the bottom of the hull, though sometimes she may discharge the mud into barges brought alongside. It will be seen that the *Peluse* has been very efficiently protected against any damage which might be inflicted by another vessel coming alongside her. These vessels are given very powerful machinery, which drives both the propellers and the dredging apparatus, an arrangement allowing the latter to be connected with the main engines. The most modern example of this type has triple-expansion engines and twin-screws, so that she is entitled to more respect than her unwelcome appearance might suggest.

The suction-dredger, on the other hand, as its name signifies, does not scoop up the sand, but sucks it up into her holds through pipes which reach down to the bed of the river or estuary. The largest of these is well-named, and is illustrated opposite page 226. This represents the *Leviathan*, which is owned by the Mersey Docks and Harbour Board, Liverpool,

THE PADDLE-TUG "DROMEDARY."

From the Model in the Victoria and Albert Museum.

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THE BUCKET-DREDGER "PELUSE."

From a Photograph. By permission of Messrs. Lobnitz & Co., Ltd.

and it is through her work that the river is able to be maintained in a navigable condition. This voracious animal sucks up sand at the rate of 10,000 tons in less than an hour, by means of centrifugal pumps, and when loaded with this heavy cargo steams out to sea at a speed of ten knots, and then by means of doors discharges the sand through her bottom. The doors are worked by means of hydraulic machinery. She herself is propelled by four sets of triple-expansion engines, which also work the centrifugal pumps. We can get some idea of the size of this dredger when we remark that her enormous length of 500 feet makes her as long as the *Etruria*.

The owners of the *Leviathan* are also the proprietors of the ship shown in our next illustration. This, the *Vigilant*, is seen alongside the crane in the Herculaneum Dock, Liverpool. The Dock and Harbour Boards are practically local Trinity House brethren, though totally independent bodies. Just as the Trinity House authorities have the upkeep of the lighthouses and lightships round the English coast, so the Dock and Harbour Boards are charged with the duties of keeping the local buoyage in efficient order for ensuring safe navigation into and out of their ports and estuaries. Gas buoys have to be refilled periodically, moorings have to be laid down afresh, and, in the case of damage, replaced. Periodically these have, in any case, to be brought ashore to be overhauled, repainted and then returned to their duties, bobbing about to the ceaseless heave of the waves. For such work as this the *Vigilant* is employed. The illustration shows a gas buoy being lowered on to her deck from the quay. Not very long ago an out-going steamship from Liverpool fouled one of the Mersey buoys in a curious manner. She was proceeding in such close proximity to the latter that she actually

caught her propeller in one of the mooring chains, with, as may be expected, consequent damage.

The introduction of electricity and the invention of the telegraph caused a new sphere of work for the steamship. For connecting land to land across the sea, cables had to be laid, and for this purpose it was thought at one time that any very large steamship would suffice. It will be recollected that the unhappy *Great Eastern* was thus employed after she had given up running as an Atlantic passenger ship. Then presently it was shown to be advisable to use specially designed ships for this purpose. The illustration facing page 244 shows an interesting little model of one of the older craft thus employed, the telegraph steamer *Monarch*, a schooner-rigged, iron, screw vessel built at Port Glasgow in 1883, for the Telegraph Department of the Post Office. Enormous sheaves are fitted at the bows as fair-leads for the cable to run out or for hauling it in. This particular ship was employed both in laying and repairing submarine cables, and could carry enough fuel and stores for six weeks' work. She had a displacement of 2,185 tons, and a single propeller driven by compound engines. The bow-sheave will be easily discerned. An earlier telegraph ship was the *Medway*, launched in 1865, and built originally for the Mediterranean trade, but she was used in the following year to help the *Great Eastern* in laying the Atlantic cable. She carried the Newfoundland end of the cable after the *Great Eastern* had gone as near in to shore as she dared. The *Medway* also carried 500 miles of cable in case the 2,730 miles which the *Great Eastern* had aboard should prove inadequate. Another converted vessel, the *John Bowes*, was used in laying the cable from Dover to Ostend, but modern telegraph ships have the dimensions

THE SUCTION DREDGER "LEVIATHAN"

From a Photograph. By permission of the Mersey Docks and Harbour Board.

THE "VIGILANT."

From a Photograph. By permission of the Mersey Docks and Harbour Board.

and general appearance of liners. The *Silvertown*, which was well-known on this work, is still afloat and to be seen in the West India Dock, London. Such modern cable-laying ships as the *Faraday* are further supplied with platforms which project from the side of the ship at the stern for greater convenience in the work for which these vessels are intended. As much as from three to four thousand sea-miles of telegraph cable can be carried by some of these ships, which, in addition to the bow fair-lead have a similar arrangement at the stern, and are supplied with all necessary grappling apparatus in case a broken cable has to be picked up.

Another special type of steamship is the oil-tanker. Owing to the nature of her cargo a steamship that carries oil is far more liable to disaster through combustion than even a cotton-ship. Oil is carried not in barrels, but in bulk. At one time it used to be carried by sailing ships in barrels, but this meant that a great deal of trouble and space were unnecessarily expended. The first tank steamer was built in 1886 by Sir W. G. Armstrong, Mitchell and Company. Carrying a cargo of petroleum in bulk is obviously a fairly risky proceeding. Firstly, there is the terrible risk of fire, more especially as the ship must have engines and furnaces; but there is also the risk of the oil obtaining a good deal of impetus, unless guarded against, as the ship rolls. It can easily be understood that so considerable a weight moving about in liquid form—a shifting cargo, in fact, of a peculiar type—is likely to cause the gravest anxiety. The illustration facing page 246 will show to what trouble the designers and builders have been put in order to devise a safe oil-carrier. This represents the interior of a modern tank steamer built by Messrs. Sir W. G. Armstrong, Whitworth and Company, Limited, by whose

courtesy this photograph of a model is here reproduced. First of all, it will be seen that the whole of the engines are placed aft, so as to be away from the dangerous oil. This characteristic, however, has recently been departed from, and in some ships the engines have been placed amidships, as in most steamships. Of this we might instance the s.s. *Phœbus*, built by Messrs. David J. Dunlop and Company, for the carrying of 9,000 tons of bulk oil. In such cases as these it is essential to insert a long, oil-tight tunnel which encloses the propeller shaft, but the drawback is that it takes up a good deal of valuable space from the ship's hold. The accompanying illustration shows the holds divided up into a number of separate compartments by means of oil-tight bulkheads, which are further subdivided by a longitudinal bulkhead. But oil possesses the properties of expansion and varies according to the prevailing temperature. It is obvious, therefore, that room must be left for expansion. To meet this, then, a long trunk or slit is left to allow the oil to expand, so that after the ship has filled her holds to the proper height the cargo may yet be allowed to become larger in bulk. The model before us shows slits at the sides at the 'tween deck, so that this expansion may take place. It will be recognised where the ladders lead down to the holds beneath. These vessels carry powerful pumps, the oil being taken on board and discharged by this means. Oil is also employed as the ship's fuel, and the boiler is kept as far away from the cargo as possible, but in order to counteract the possibility of the oil getting adrift and leaking into the after part of the ship, a separate small compartment is also added, so as more completely to divide the hold from the boiler and engines. This will be easily recognised in the illustration. The other illustration

THE TELEGRAPH STEAMER "MONARCH."

From the Model in the Victoria and Albert Museum.

DECK VIEW OF THE TELEGRAPH SHIP "FARADAY."

From a Photograph. By permission of Messrs. Siemens & Co.

facing page 246 shows a model of the *Silverlip*, also with her engines placed well aft; but this, with her derricks and her deck-houses, represents a larger and more complex ship.

We come now to a type of steamship, which, by reason of its peculiar construction, is deserving of more than ordinary consideration. Opposite page 248 we give the latest example of this type—the s.s. *Inland*. The "turret-ship," as the class is called, is of quite modern origin, and no one can come face to face with her without being instantly struck with her unusual appearance. She owes her birth to Messrs. William Doxford and Sons, Limited, of Sunderland, who are the patentees and builders of this kind of ship. It is needless to say that when this novel class of steamship first appeared in the early 'nineties there was aroused the usual prejudice; indeed, having in mind what has been the experience of other inventors in connection with our subject, the reader could hardly expect otherwise. Firstly, let us consider her with regard to her appearance. It will be seen that she differs from the usual cargo and passenger ship in that her sides tumble right in above the water-line. This forms a kind of half turtle deck, and is known as the harbour deck. But the upper deck of the "turret-ship" is extremely narrow. (This will be seen more easily by reference to the next illustration, which gives a model of the midship section of such a ship.) The harbour deck need not be used except when in port, but it can be employed for stowing long timbers or even iron girders if required. Like the oil-tanker, many of the turret-ships have their engines placed right aft, so that there is a long clear space for stowing the cargo in the hold, an advantage which is especially appreciated in the carrying of certain kinds of cargoes. Just as we saw there was great danger to a ship

in the possibility of oil washing about the hull and shifting in a perilous manner, so also there is a danger in such cargoes as rice and grain. With regard to the latter, I remember the case of a big cargo ship which had the misfortune to spring a leak and the water swelled the rice to such an extent that the ship, strong as she was, burst her sides. But in the case of grain the danger is not merely that, but also of shifting. As guarding against this possibility the turret-ship, by reason of her special design, is specially suitable, for any shifting that may take place in the turret matters but little, and whatever shifting may take place in the hold is compensated for by the turret; the cargo can be shot into the hold without needing any trimming. The deck of the "turret" portion will be seen from the illustration facing page 248 to form a navigating platform.

Some of the modern turret-ships are fitted with twelve or fourteen masts arranged in pairs, each pair being across the ship instead of fore-and-aft-wise. These vessels have proved themselves to be excellent sea-boats, and owing to their high freeboard and the harbour deck, which acts as a kind of breakwater, it has to be a very bad sea indeed that will break over the ship. Furthermore, the harbour deck tends to reduce the rolling of the ship, for when one side of the ship heels over so that one harbour deck is under water, the windward side, when it holds a certain amount of water, actually tends to bring the ship back to her level. Moreover, since these decks are unencumbered with obstructions, they can suffer no damage through the wash of the sea. They are also extremely strong ships, for the sides of the turrets increase the strength of the vessel longitudinally, while the curved formation of the harbour deck augments their strength transversely; their simplicity of construction and their adapta-

SECTION OF MODERN OIL-TANK STEAMER.

Photograph from a Model. By permission of Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd

THE "SILVERLIP."

From the Model in the Victoria and Albert Museum

bility for almost any cargo still further add to their virtues. But from the view-point of the owners the turret-ship is even still more a welcome type of craft, in that since dues are paid on a ship's registered tonnage the turret-ship is able to carry far more cargo in proportion to her size than most vessels. On a small registered tonnage the turret-ship has an exceptionally large dead-weight capacity, and those parts of her which are liable to be taxed are diminished as far as is possible, whilst at the same time greater space is allowed to the carrying and handling of the cargo. Economically, then, the turret-ship, with her odd shape, her many masts and derricks, is a very advantageous carrier.

A good deal of interest has recently been aroused by the peculiarities of a steamship named the *Monitoria*, which, though not a turret-ship, is sufficiently out of the ordinary design to warrant special mention. She is just an ordinary single-deck cargo steamer, but instead of the usual wall-sided shell-plating has two longitudinal corrugations along the outside of her hull. These swellings, so to speak, extend below the water-line and gradually merge into the ship's lines at bow and stern. The claim made for this novelty is that it is effective in reducing the wave-like irregularities, and allows of more power being available for propulsion, whilst it also lessens the rolling and pitching of the ship. The captain of this ship is reported to have said that these corrugations had a beneficial effect on the steering, whilst the wake of the ship was found to be smooth and about half the width instead of the full breadth of the ship. Very interesting as practical comment on a subject that we have treated elsewhere in this volume, is her commander's remark that whilst in a diagonal sea, which was running at a height of 9 feet or 10 feet, a ship

of ordinary form and the same dimensions as the *Monitoria* would have been safe proceeding at no higher speed than 6 or 6½ knots, yet the *Monitoria* was safe going ahead at 7¼ to 7½ knots. The corrugations are said also to increase the ship's buoyancy, and thus admit of three per cent. more cargo being carried, while the hull is more readily able to resist the strains than vessels of ordinary shape. It is probable that this novel principle will be presently exemplified in a first-class liner, and in a foreign cruiser.

Similar to the turret-type is the "trunk-deck" steamer, which possesses like advantages. She resembles in appearance the former type, but instead of the curves (seen in the *Inland*) at the gunwale and bases of the turret or "trunk," the sides of the trunk rise from the main deck nearly at right angles, the harbour deck being really a true deck. This kind of ship owes her birth to Messrs. Ropner and Sons, of Stockton-on-Tees. Such vessels afford even more than the turret-ships the appearance of a kind of up-to-date man-of-war, without the guns which one would almost expect to see protruding from behind some of her steel plates. It should be borne in mind that both the turret and the trunk type possess an absence of sheer, for the height of the lofty turret, or trunk, enables this to be dispensed with, while to make up for this lack of sheer from the bows to the stern, the vessel is given a top-gallant forecastle.

When a vessel is carrying her full cargo her stern is sufficiently immersed to prevent her propeller from racing badly in a heavy sea. But when she is making a voyage "light" there is great danger of damage to the ship through the fracturing of the propeller shaft as the ship dips her bows and raises her tail in the air. Everyone who has had experience of hand-

THE TURRET-SHIP "INLAND."

From a Photograph. By permission of Messrs. W. Doxford & Sons, Ltd.

MIDSHIP SECTION OF A TURRET-SHIP.

From the Model in the Victoria and Albert Museum.

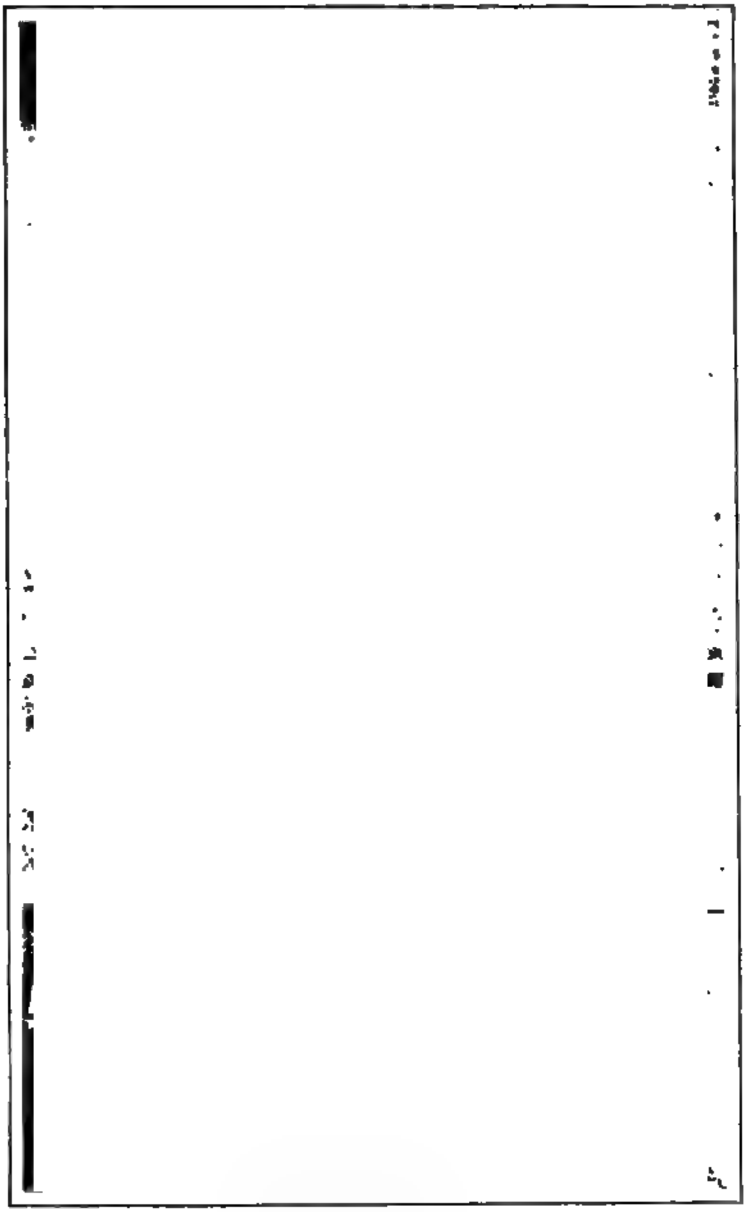
ling small craft of any kind is aware that the lower the ballast is placed the more the ship will roll. In an extreme case, when all the ballast is placed outside the ship on to her keel, the motion in a sea-way is more like that of the pendulum than anything else. The method which we are now about to discuss allows of water-ballast tanks being placed sufficiently high at the "wings" to counteract this rolling. Opposite page 250 will be seen two illustrations of the patent cantilever-framed steamers which are built by Messrs. Sir Raylton Dixon and Company, Limited, of Middlesbrough, through whose courtesy the photographs are reproduced. By examining them it will be seen that water-ballast can be carried not only in the usual tank at the bottom of the ship, but in the wing tanks at the sides of the ship, and at such a height that when the ship is crossing the ocean without cargo, she will have an easy motion.

The lower illustration shows a section of one of these cantilever ships, and the water-ballast tanks, above which is a shelter deck that in the case of a passenger ship can be used as a promenade, or can accommodate live cargo in cattle-ships. It will be noticed that the ship's frames are bent inwards, and that these, together with the vertical sides of the hull, form the triangular spaces for the tanks. Now these tanks run fore and aft on both sides and increase the strength of the ship, not merely longitudinally, but transversely. Owing to this the necessity of adding such obstructions to the hold as pillars and beams vanishes, and as will be seen in the illustrations, the hold is thus free and unencumbered for all manner of cargo. It is further claimed for this cantilever craft that she can carry a dead-weight more than three times the net register, and since these tanks are not reckoned into the tonnage they increase the safety and comfort of the ship without

detracting from her utility. The reader will also notice in the upper picture to what an enormous extent the modern steamship is now being fitted with extra derricks, with a cross-piece up the mast to take the strain involved in working the latter.

As the reverse of being specially adapted for a particular service, the steam tramp is built so that she can readily engage in almost any carrying trade. Unlike the liner with her fixed routes and set times of departure and arrival, the tramp is a nomad, and wanders over the world picking up a cargo here and there, and taking it across the ocean at her economical but jog-trot speed. If there is nothing for her to pick up at the last port of call she betakes herself elsewhere with the hope of better luck. Her main income is derived as a coal-carrier, and for this she is quite suited. But the modern collier—the kind of ship which is expressly built for the coal trade—is fitted with numbers of steam winches in keeping with the modern feverish haste and hurry, so that no sooner has she come alongside than she may instantly begin to unload. In old-fashioned times the discharging was done from the shore, but nowadays the up-to-date turret-ship makes short work of handling her black diamonds. Special appliances are also provided for those steamships which bring over the seas vast quantities of New Zealand mutton, fruit, and other perishable articles of food. Elaborate refrigerating machinery has to be installed in the ship, and special means employed to facilitate the disembarking of the cargo, especially in the case of the former.

To a still more exceptional purpose has the steamship been adapted in order to act as an ice-breaker and give liberty to those ships which, in certain parts of the world, have, with the approach of winter, been compelled to enter a lengthy



CANTILEVER-FRAMED SHIP.

By permission of Sir Raylton Dixon & Co., Ltd.

imprisonment. Such localities are found in both Canada and Russia. Thanks to the ice-breaker steamship it has been made possible to keep open the Baltic ports with a passage of sufficient width. Constructed of a strength which is possessed by no other vessel than a man-of-war, the ice-breaker attacks the frozen masses as a battleship used to ram her foe. She goes for the ship's enemy with her curved bow, and wages war with all the ability which the ship-builder and naval architect have given her. Her bow is specially strengthened to suffer the force of the contact with the heavy ice masses, and the lines of the hull are such that the ice in its endeavour to crush the ship finds difficulty in getting a good grip upon it. Nevertheless, these ships are fitted with numerous water-tight compartments. Their means of propulsion are, of course, screws.

Similarly, across the North Atlantic, the steamship on the Great Lakes, where for one third of the year the water is frozen, has to battle with the ice-fiend. Ordinary steamers have to be laid aside, but the train-ferry steamship still goes on with her work, being specially designed to break through the impeding ice. As in the Russian ice-breakers, so here the principle employed is that the ship shall forge her way unto the ice, and by means of her overhanging bow, and its weight, shall break through the obstruction.

Across the wide harbour of New York the steamship train ferries, carrying rolling stock run aboard by lines, are employed to an extent that is strange in comparison with English customs, although the idea is not new to the Mersey, and the evergreen scheme of instituting a ferry of this nature across the English Channel to France, so that international travellers can go from Charing Cross to the other end of the world without having

to change their compartments, is still advocated with enthusiasm.

We pass now to another type of steamship, which is endowed with as much distinctive character as the steam tug. The steam trawler may not be as smart as a steam yacht nor as fast as a torpedo destroyer; yet, for all that, she is able to encounter as bad weather and—size for size—is perhaps a good deal better sea-boat. In the North Sea, which has been the favourite cruising ground of the steam trawler, there is to be encountered as nasty and dangerous a short sea as can be found, perhaps, in any other part of the world. In all weathers, and at all times of the year, the trawler has to go about her business, and the comparatively few disasters that overtake her is a credit at once to the seamanship of her skipper and the seaworthiness of the little ship herself. Opposite this page we show a photograph of a typical North Sea steam trawler. This is the *Orontes* of Hull, built in 1895, of iron, by Messrs. Cochrane and Sons, of Selby. She measures 110 feet long, 21 feet wide, and 12 feet deep, her net tonnage being 76, and her horse-power 60. The evolution of the steam trawler was on this wise: When the value of steam had been shown to be worth the consideration of the fisherman he responded. At first the old-fashioned paddle-steamer was used tentatively on the north-east coast of England, and the writer remembers in the early 'eighties the singular unattractiveness—the total absence of beauty, indeed—which these vessels possessed. By birth and adoption these were properly tugs, but they did a bit of trawling on their own account when not otherwise required, and met with sufficient success to repeat the experiment many times. Some of these ugly old craft are still to be seen in the neighbourhood of Scarborough and Whitby.

THE NORTH SEA TRAWLER "ORONTES."

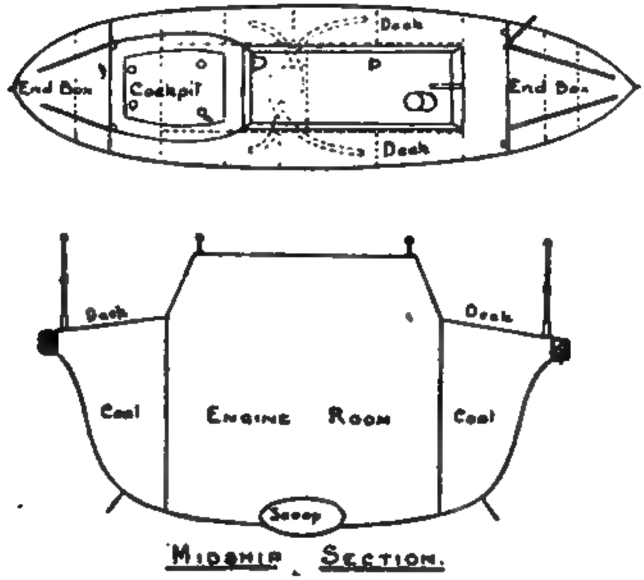
THE STEAM TRAWLER "NOTRE DAME DES DUNES."

From Photographs. By permission of Messrs. Cochrane & Son, Selby.

But since the fishing fleets were at sea for weeks together, and something faster than a sailing ship was required to hurry the cargoes to market, a special steam fish-carrier came in which plied her voyages from the Dogger to London and the east coast ports. From that it was an easy step to building a steamship for use not as a carrier but as a trawler. Already steam had been in use on board the sailing trawler, but that had been for hauling the nets and warping into dock. The increase of competition, the loss of a market through calms and the prevalence of head winds, clearly marked the way for the coming of the steam trawler. Recently it has been shown that the employment of the motor-propelled trawler means a saving of cost and a greater share of profits to all concerned, and perhaps in the next decade the steam trawler may find the more modern form of propulsion to be a serious rival. But even now sail has anything but vanished, and there are many purely sail-driven trawlers, as also there are many steam trawlers with auxiliary sails. Within the last few years the steam fishing ship has grown to be of considerable size, with topgallant forecastle, high freeboard and lofty wheel-house, so that it penetrates to oceans thousands of miles away from the North Sea, being enabled by reason of its size to carry sufficient quantities of coal for many miles. The lower illustration facing page 252 shows one of the modern type of steam trawler. This is the *Notre Dame des Dunes*, built by the same makers as the *Orontes*. Her substantial forecastle, her bold sheer and high bows, together with her length (rather more than six beams to the longitudinal expanse), eminently fit her for her work in most trying circumstances. A curious survival of the old-fashioned sailing ship is seen in the retention in a twentieth century ship of the imitation square ports painted

along her topsides. The *Notre Dame* measures 160 feet long, 25 feet wide, and 14½ feet deep.

But to-day, even with all the modern improvements which have been put into the ship, both sailing and steam-propelled; notwithstanding all the navigational appliances, the water-tight compartments, the size of ships and the excellence with which they are sent on their voyages, there is still need for the lifeboat, which has to go out many times during a bad winter at the summons of necessity. Although it is possible that the motor, as in the trawler, will eventually oust steam from this special type of craft, that stage has not yet been reached. Steam is a comparatively recent innovation to the lifeboat, and this is partially explainable by the deep-rooted prejudice of the local seamen. It is also owing to the fact that when the lifeboat has to go out at all the seas are very bad, and the craft is subjected to the water breaking over, and unless special precautions were taken to guard against this the fires would be put out, and the boat would be rather worse off than if she had no engines. There are only a few steam lifeboats along our shores, and they are placed at such stations where they can lie afloat instead of having to be launched down the beach or from a specially constructed slip-way. The first form of steam lifeboat was to some extent on the lines of the ship which John Allen had suggested as far back as 1780, of which we spoke in an earlier chapter. It will be remembered that he advocated a system which was actually employed by James Rumsey in 1787. The principle was that of sucking water in at the bows and ejecting it at the stern. A more recent instance of the use of this idea will be found in the boat illustrated on the opposite page which shows a hydraulic lifeboat. The disadvantage of having a screw

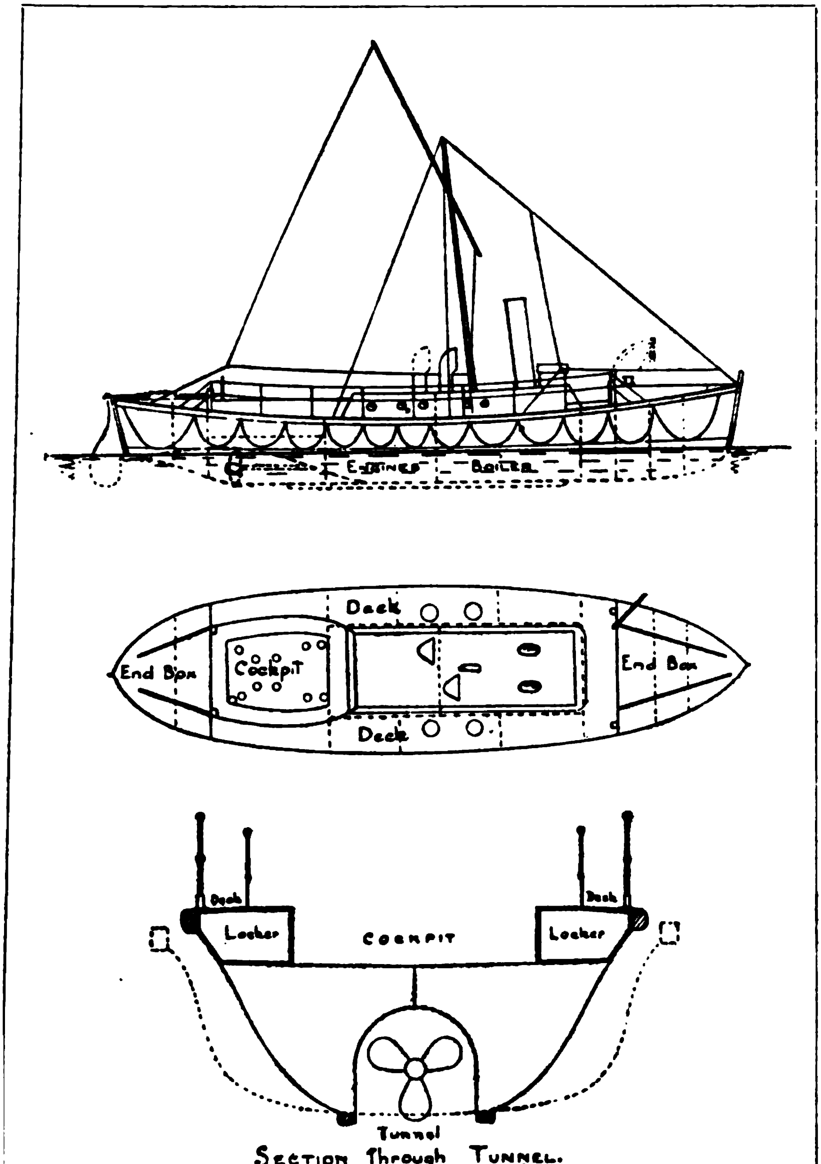


HYDRAULIC LIFEBOAT.

By permission from "The Yachting Monthly."

propeller is that it stands a very good chance of being fouled, if not damaged, by wreckage and ropes. Therefore engines were installed which sucked in the water by means of a "scoop," placed at the bottom of the boat amidships. The water thus indrawn is discharged aft on either side of the hull, and if the craft is desired to go astern, then this is easily done by discharging water forward. This type has been in actual use, and has been highly efficacious in saving human life from shipwreck. By referring to the lower figure of the illustration on page 255, which shows the midship section of one of the hydraulic type, some idea will be gained of the placing of the "scoop." By using alternately one of the after pipes the ship can be manœuvred to port or starboard just like a vessel fitted with twin-screws. But there are corresponding disadvantages which require to be weighed. It is distinctly not an economical method of propulsion, and if the sea happens to contain much sand considerable damage may happen to the engines, and other undesirable matter also may work still greater havoc.

On the other hand, we have mentioned that the screw has its drawbacks owing to the possibility of its suffering injury. It was therefore decided that this could be avoided by placing it in a tunnel some distance forward of the stern, and thus protected against all likely damage. (A similar method is also employed in the steam fire-boats which are used by the London Fire Brigade on the Thames, and are summoned whenever a river-side warehouse or factory gets ablaze.) If reference is made to the illustration on page 257, this tunnel will be discernible. In order to leave nothing to chance a water-tight hatch is placed in the cock-pit floor just over the propeller, through which any pieces of sea-weed, rope, or other undesirable matter can easily be removed without



A SCREW LIFEBOAT.

By permission from "The Yachting Monthly."

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having to beach the craft first. These little ships measure about 50 feet long, and about 15 feet wide; they are driven by direct-acting, compound, surface-condensing engines, which give to them a speed of about nine knots.

In certain parts of the world where the rivers are shallow, either at their banks or in mid-stream, steam navigation is only possible by means of "stern-wheelers." Such instances occur on the West Coast of Africa, and also in America. In general idea, though not in detail, this method is a reversion to the antiquated ship already discussed in Hulls' idea for a tow-boat. The stern of these steamships to which we are referring is not ended in the same continuous straight line, but is raised slightly upwards at an angle so that the paddle-wheel is able to revolve freely without requiring such a draught of water as otherwise it would have needed if placed on the ship's side in the usual manner. This will be seen on examining the stern of the *Inez Clarke*, illustrated opposite this page. This stern-wheeler was built as far back as 1879, but the points on which we are insisting are here well demonstrated. The draught of the ship, notwithstanding the weight of her engines, was only 15 inches, so that she was enabled to go into the very shallowest water, where even a bottle could float. Nevertheless her stern-wheel was sufficiently powerful to send her along at 15 miles per hour. Her measurements are 180 feet long, and 28 feet wide. Steamboats possessing a similar principle to that exhibited in the *Inez Clarke*, but much different in the arrangement, are to-day in use on the Ohio and Mississippi Rivers, being used as tugs to tow along a large fleet of flat-boats containing coal. As much as fifty to sixty thousand tons are taken in tow at one time.

To North America, with its fine long rivers, the steam-

THE "INEZ CLARKE."

From the Model in the Victoria and Albert Museum.

THE "NATCHEZ" AND THE "ECLIPSE" (1855).

THE "EMPIRE."

From the Model in the Victoria and Albert Museum

boat has been, as Fulton in his foresight prophesied it would be, a highly useful institution. To the European mind the vast possibilities of the mighty Mississippi come as a shock when fully realised. To quote the very first sentence in one of the most popular books which that most popular writer, Mark Twain, ever wrote, "The Mississippi is well worth reading about"; so, also, we might add, are its steamboats, but in our limited space we can only barely indicate some of their essential features. The illustration facing page 258 shows a couple of these, the *Natchez* and the *Eclipse*, racing against each other along this great river by the light of the moon at midnight. The first thing that strikes the attention is the enormous height to which the decks of these steamboats are raised. The pilot-house is higher still, and will be recognised as about midway between the water-line and the top of the long, lanky funnels. Even to Mark Twain the height seemed to be terrific. "When I stood in her pilot-house," says the author of "Life on the Mississippi," "I was so far above the water that I seemed to be perched on a mountain; and her decks stretched so far away, fore and aft, below me, that I wondered how I could ever have considered the little *Paul Jones* a large craft. When I looked down her long, gilded saloon, it was like gazing through a splendid tunnel. . . . The boiler deck—i.e. the second storey of the boat, so to speak—was as spacious as a church, it seemed to me; so with the forecastle; and there was no pitiful handful of deck-hands, firemen, and roust-abouts down there, but a whole battalion of men. The fires were fiercely glaring from a long row of furnaces, and over them were eight huge boilers."

The accompanying picture, which is taken from a lithograph printed in 1855, shows two of the finest contemporary Mississippi

steamboats. The *Eclipse* was propelled by a high-pressure engine with a single cylinder, the paddle-wheels being 40 feet wide. Her two boilers were placed forward about 8½ feet above the deck, having internal return tubes, such as we discussed at an earlier stage. The waste gases returned through the tubes and escaped through the funnels, which rose 50 feet above the hurricane deck. This ship only drew 5 feet, and measured 360 feet long and 42 feet wide, whilst the hull was 8 feet deep. For fuel, rosin and pitch pine as well as coal were used. Mark Twain has left us some details of the keenness with which these and similar Mississippi steamboats used to race.

" In the olden times," he wrote, " whenever two fast boats started out on a race, with a big crowd of people looking on, it was inspiriting to hear the crews sing, especially if the time were night-fall, and the forecastle lit up with the red glare of the torch-baskets. Racing was royal fun. The public always had the idea that racing was dangerous; whereas the opposite was the case. . . . No engineer was ever sleepy or careless when his heart was in a race. He was constantly on the alert, trying gauge-cocks and watching things. The dangerous place was on slow, plodding boats, where the engineers drowsed around and allowed chips to get into the 'doctor,' and shut off the water supply from the boilers. In the 'flush times' of steam-boating, a race between two notorious fleet steamers was an event of vast importance. . . . Every encumbrance that added weight, or exposed a resisting surface to wind or water, was removed. . . . When the *Eclipse* and the *A. L. Shotwell* ran their great race many years ago, it was said that pains were taken to scrape the gilding off the fanciful device which hung between the *Eclipse's* chimneys

and that for one trip the captain left off his kid gloves and had his head shaved. But I always doubted these things."

In 1870 the *Natchez* ran from New Orleans to Natchez, a distance of 268 miles, in seventeen days seventeen hours. The most famous race of all, and one that created national interest, was that in the year 1870, between the *Robert E. Lee* and the *Natchez,* from New Orleans to St. Louis, a distance of 1,218 miles. The former covered the journey in three days eighteen hours fourteen minutes, the latter in three days twenty-one hours fifty-eight minutes, but the officers of the *Natchez* claimed seven hours for having had to stop through fog, and repairs to the machinery.

But let us pass further North. The Hudson has, since the time of Fulton, been famous for its steam-craft, and the impetus which necessarily followed after the success of the *Clermont,* and her successors, has not yet ceased to exist. As representative of the Hudson River type of boats in vogue during the 'sixties, the model of the steamer *Empire* facing page 258 is not without interest, since it shows, the half-way transition between the *Clermont* and the ultra-modern built-up ship as in the illustration facing page 262. Like her other sisters, the *Empire,* it will be seen, has a very light draught, and a characteristic feature of the development of the North American passenger side-wheel steamer is here to be noted in embryo, and as pushed to its furthest limits, in the case of the *Commonwealth.* I am calling attention to the manner in which the American custom extends the steamship's sponsons or " guards " (as they are called). In a British paddle-wheel steamer, such as one finds employed on passenger or tug service, the sponsons are quite short. (This can easily be seen by reference to the *Dromedary* opposite page 204.) But the

American fashion is to allow these not to end suddenly, but gradually fine off at bow and stern so that the deck is carried well out-board. Forward is the pilot house, the passenger accommodation being provided in the centre of the "guard" deck and upper deck. The length of this vessel was 386 feet, whilst the breadth of the hull proper was 28 feet, though including "guards" 61 feet. In many of the Hudson steamers the strange sight is still seen of the use of the old walking-beam which penetrates through the top of the deck. As we have already discussed this elsewhere, it is scarcely necessary here to refer to it further, but the sectional model illustrated opposite this page will show quite clearly this principle.

One of the best known steamship companies in the United States is the Fall River Line, belonging to the New England Navigation Company. The Fall River Line runs from New York to Boston, and their vessels are of exceptional interest as being propelled by paddle-wheels notwithstanding that their size is in some cases of from four to six thousand tons. Characteristic, too, is the extent to which the decks tier aloft and spread out beyond the hull of the ship. Among their fleet may be reckoned the *Priscilla, Puritan*, and *Providence*, vessels which vary in length from over, to just under, 400 feet, with a beam of about 50 feet, but including "guards" about another 30 feet. Opposite this page will be seen the *Commonwealth*, the flagship of this celebrated fleet, and the most modern. Instead of the paddle-boxes rising to a great height, they are absorbed by the excessive amount of top-hamper. To such an extent, also, has the widest beam of the ship been pushed that the paddle-wheels are scarcely discernible, being quite underneath the "guards," instead of projecting from the hull. The *Commonwealth* plies between

THE "COMMONWEALTH."

BEAM ENGINE OF AN AMERICAN RIVER STEAMER.

From the Sectional Model in the Victoria and Albert Museum.

New York and Boston via Newport and the Fall River, and is the largest and most magnificent steamship built for service on inland waters. Some idea of her value may be gathered when we remark that she cost £400,000 to build. It will be seen that she has been given a high bow, for the reason that she must be a good sea-boat, since part of her route is exposed to the Atlantic. She is 456 feet long, 96 feet wide (reckoning in the "guards"), and has sleeping accommodation for two thousand people. This voyage is performed in about twelve hours, mostly by night, from New York to the Fall River, and the retention of the paddle-wheel gives an absence of vibration, and enables the nerve-wrecked citizen to sleep as peacefully as on shore. The *Commonwealth* is steady in a sea-way, and has pushed the cult of luxury just about as far as it can go, whilst yet retaining any of the accustomed characteristics of the ship. Practically these craft are remarkably up-to-date hotels moved by a pair of paddle-wheels. Replete with their barber's shops, cafés, libraries, saloons, orchestra, galleries, stairways, dining-rooms, spacious bedrooms, kitchens, and other features too numerous to mention, they are representative afloat of the prevailing passion ashore for luxury and personal comfort. The *Commonwealth,* like her sisters of the same fleet, is built of steel, and for greater safety she has seven bulkheads, which extend to the main deck, and are so installed that no carelessness can leave the doors open. Her hull is double and the space between the bottoms is divided into numerous water-tight compartments, whilst collision bulkheads are also placed at each side of the steamer at the "guards." Her speed is twenty-two knots per hour, which is obtained by compound engines, with two high-pressure cylinders. The paddle-wheels are of the feathering type, with curved steel buckets,

and in addition to the usual steam pumps, there is a large pump for use on the fire-sprinkler system which covers the whole interior of the ship. The ship has a powerful search-light, and an electric lift to the kitchen. In case both her steam-steering and hand-gear should get out of order the ship can be steered by independent auxiliary gear attached direct to the rudder stock.

Having regard to the fact that it was North America which played so prominent a part in the history and introduction of the steamship, it is by no means unfitting that that country should also have developed the paddle-wheel steamboat to an extent that is entirely unknown in Great Britain. The difference in types is partly owing to the difference in tastes and habits between the two peoples, but also owing to the contrast in geographical arrangement. We in England have nothing comparable with the Hudson, for instance, and its fine, long sweep of navigable water; nor with the vast American Great Lakes, which, in a unique manner, have held out a special kind of encouragement to the steamship. As carriers not merely of cargoes, but also of passengers, especially during the tourist seasons, the steamships on the Great Lakes have attained the character rather analogous to the ocean liner than to the inland steamboat. The spirit of luxury is not concealed in these Lake liners, and some idea of one of the two-funnelled passenger steamboats now plying on the Great Lakes of America may be seen in the illustration facing this page of the *City of Cleveland.* The two characteristics already noted in the case of the Hudson and the Fall River steamships will here be noticed still further. We refer to the extent of the added decks, and to the increased beam which is given to the ship by means of the "guards."

THE "CITY OF CLEVELAND."

AN AMERICAN "WHALE-BACK" STEAMER.

But perhaps the most extraordinary looking American steamship is the well-known "whale-back" which is in use on the Great Lakes as a cargo-carrier. Practically speaking she is just a whale-like steel tank with an engine and propeller at the stern. Anything but comely in appearance, she is something of the American counterpart of the British turret-ship, but with one difference. The American type has no turret, but is just a long curved box with two comparatively small erections at bow and stern respectively, as will be seen by examining the photograph of one of these vessels reproduced opposite page 264. But the design of these Lake steamers is to carry the largest amount of cargo with the lowest registered tonnage, and this object is attained with satisfactory results, for there is scarcely any space at all in the ships but is thus employed.

And with this we may bring our chapter to an end. We have now seen the rise, the gradual growth, and the specialisation of the steamship in many ways, and in many different localities whenever employed as a commercial money-earning concern. But the steamship, like the sailing ship, is not exclusively employed either for commerce or for war. With the latter kind of ships we have in the present volume no concern; but with regard to the development of the steam yacht we shall now have something to say.

CHAPTER X

THE STEAM YACHT

THAT the steamship should become for the sportsman what for some time the sailing vessel had been was a natural prophecy. Even if steam were not to oust the simpler craft, at least both might sail the seas together without let or hindrance. But, of course, the old prejudice asserted itself again in yachting just as we have so frequently through the pages of this book seen that it did in the evolution of the purely commercial and experimental ships.

The pioneer of the steam yacht was undoubtedly the late Mr. Assheton Smith, of Tedworth, near Andover. A man of substantial means, a keen sportsman, who was well-known among both hunting and yachting men, he was rather more far-sighted than his contemporaries, and considerably less prejudiced. He had owned a number of sailing yachts, was a member of the Royal Yacht Squadron, and had it in mind to extend the encouragement of the sport also to vessels using steam. But to the select and conservative minds of the Royal Yacht Squadron this was by no means a happy suggestion, and they promptly showed their resentment by passing a resolution on May 5th, 1827, to the effect that since a material object of the club was to promote seamanship and improvements of sailing vessels to which the application of steam-engines was inimical, no vessel propelled by steam should be admitted into the club, and that any member applying a steam engine to his yacht should cease to be a member. As

the late Mr. Montague Guest, in his history of the Royal Yacht Squadron, remarked, this prejudice was no doubt caused by the objectionable vomits of smoke which contemporary steamers in that locality were wont to emit, so that the fair shores of Southampton Water were polluted, and distant objects completely obscured. Smith was taunted with the remark that in wishing to introduce the steam yacht he was intending to make a connection between business and pleasure, and this insult stung him so severely that he eventually resigned his membership.

In August of 1827, the Northern Yacht Club offered at their regatta a twenty guinea cup, to be awarded to the swiftest steamboat, and so far as I am able to ascertain this was the first occasion when steam craft ever raced against each other under such conditions. Several steam vessel owners sent in their entries for the race, and after an exciting contest for three hours round a marked course, a paddle-ship, named the *Clarence*, won. This is especially interesting, inasmuch as that boat had been engined by the famous Robert Napier to whom we referred earlier in this book, and in more ways than one this success led to considerable success. The incident attracted the attention of Assheton Smith, who, although he was then fifty years old, was fired with enthusiasm over the possibilities of the new sport. He had already had five sailing yachts built for him, and after resigning from the Royal Yacht Squadron, wrote to Napier asking him to come south to his place near Andover. Neither had met before, and the upshot of the northerner's visit was that he was commissioned to build a steam yacht, the cost of which came to £20,000, Napier being given a free hand in regard to her entire construction. A recent writer has seen fit to remark that " no account exists

of the first steam yacht built by Mr. Smith," so that it may be worth while to add that this vessel was named the *Menai*, that she was built in the year 1830 and delivered at Bristol. She measured 120 feet long and 20 feet wide, her tonnage being 230, and her nominal horse-power 110. She was, of course, a paddle-wheel craft and driven by Napier's double side-lever engines, of which we have already explained the detailed working. Those who wish to see what this first historic steam yacht was like can examine a model of her in the Glasgow Art Galleries.

The *Menai* turned out a great success, and so pleased was her owner, that he commissioned Napier to build him another boat, which was named the *Glowworm*, a vessel of 800 tons and 100 horse-power. She was made ready by 1888. Until Smith was eighty years old the connection thus formed between the two men was continued, and during the period of twenty or thirty years Napier built quite a fleet of steam yachts for his patron. The *Glowworm* was followed by the *Fire King* in 1839—this being a 700-ton ship and the biggest of them all. Afterwards came at different dates three *Fire Queens* (in honour of Queen Victoria, who had come to the throne since the first steam yacht had been launched), the *Jenny Lind*, and the *Sea Serpent*; the latter about 1851. The *Fire King* was designed with hollow water-lines, and was a vessel possessing considerable speed. Before her trials were run, Smith issued a public challenge in *Bell's Life* that she would run against any steamer then afloat, from Dover Pier to the Eddystone Lighthouse and back, for 5,000 guineas, or even higher stakes if desired. One of the three *Fire Queens* was the fastest vessel of any kind at that time, and possessed the exceptional speed of 16 knots. This was the third vessel of that name, and was

built in 1846, her tonnage being 800 and her horse-power 120. She was driven by steeple engines which actuated a screw, and the Admiralty thought so much of her that they purchased her as a packet. Smith, however, did not like the screw, and his next ship reverted to the use of paddle-wheels.

In 1844 the Royal Yacht Squadron began to climb down gradually from their haughty position of serene isolation, for in that year they showed some slight recognition of the steam yacht by resolving that "no steamer of less than 100 horse-power should be qualified for admission into, or entitled to the privileges of the Squadron," and in 1858 the last objection to the steam yacht was withdrawn by the rescinding of all rules which prohibited her use. Thereupon a number of the Royal Squadron members had auxiliary engines fitted to their sailing craft, but by 1856 there were not more than a score of steam-engined yachts as against seven or eight hundred sailing ones. In 1868 a unique race, which excited some derision at the time, was run between Lord Vane's steam yacht *Cornelia* and Mr. Talbot's *Eothen*. During the early 'eighties many of the non-racing yachts flying the Squadron's colours, and used solely for cruising, were either purely steam or auxiliary steam yachts. By 1888, out of 2,000 yachts no fewer than 700 were steam, which had cost originally two and a half millions sterling. To such an extent had this new development of the sport gone ahead that it was even seriously suggested by the *Field* that ordinary cruising would be extinguished by the steam yacht. During the 'eighties the number of English steam yachts multiplied in all parts of the Kingdom owing to several causes. The improvements which had been going on, as well in the making of marine engines as in yacht building and designing, were assisted by the more economical consumption

of coal which was now possible. But the sport of steam-yachting is entirely, by reason of its nature and its costliness, confined to the rich man. Apart altogether from the advantages which steam gives in that it renders the yacht independent of calms and tides, yet it carries with it especially a social feature. The influence of Cowes week, the dispensing of hospitality, and the privilege of enjoying a floating home anything but bereft of the highest comfort, must be reckoned as among the potent factors of an extent equal to, if not greater than, the sheer delight of voyaging from one port to another. Many steam yachts spend their time within the comparatively sheltered waters of the south coast of England, or the west coast of Scotland, perhaps running out to the Riviera in December or January. But a few, such as Lord Brassey's celebrated *Sunbeam*, go round the world, penetrate to the Arctic circle, cross the Atlantic, and go east through the Suez Canal.

For a long time the steam yacht naturally enough retained most of the features of the sailing yacht. I say naturally, not merely because steam was still distrusted, and, therefore, canvas was retained, but because beauty of form and symmetry are demanded more in the steam yacht than in the steamship designed for commercial purposes. For the creators of steam yachts were rather yacht-architects than steamship-designers. We have only to quote the admirable work of such men as St. Clare Byrne and G. L. Watson to emphasise this point. Indeed, with the exception of the *Triad*, so recently added to the fleet of steam yachts, and to which we shall refer fully in due course, the lines and general appearance of the steam pleasure vessel is far more "yachty" than perhaps one might have imagined would be the case, having regard to the differences

TYPICAL STEAM YACHT OF ABOUT 1890.

By permission of "The Yachting Monthly."

which have sprung up in the appearance of the commercial steamship. The illustration on page 271, which is typical of the steam yacht about the year 1890, shows how markedly the influence of the clipper sailing ships of the 'sixties was at work. The gilding at the bow, the figure-head, the fine entrance, and the bowsprit have existed long after the latter was required for setting a jib at the end of it. As a rule, the schooner rig has prevailed, though some ocean-going steam yachts are rigged as barques, ships, and barquentines. For long voyages between distant ports the retention of the sail as a saving of the limited coal supply is but natural, and also for the purpose of steadying the ship in a sea-way.

In the early days the steam yacht was usually of the type which has one flush deck. But to-day she varies to the same extent as the sailing yacht. Topgallant forecastles, quarter decks, bridge-houses, awning decks, shade decks, spar decks, and many other features have been added. Three masts have given way to two, and now only one is being retained, and that merely for signalling purposes or for wireless telegraphy. Formerly, the steam yacht was a long, narrow creation carrying a considerable quantity of ballast, but to-day she is given greater beam, and in many points is coming far more under the sway of the ocean steamship than ever she has in the whole of her history. The accommodation is being modified and improved, and the elemental features are undergoing a change. Whereas the older types carried their dining and drawing-rooms below, nowadays these, as well as the state-rooms, are, whenever possible, placed on the main deck. Much more room is afforded for promenade by the adding of deck upon deck, and a noticeable characteristic of the modern steam yacht is the extent

to which the deck-house and pilot-house have been carried. Like their bigger sisters, the steam yachts of to-day are fitted with every thought for comfort. Electric light, refrigerating plant, exquisite decorations, heating apparatus, search-lights, and a thousand other details go to swell the long bill which has to be paid for the private steamship.

The old square stern inherited from the Dutch, through the British Navy of yesterday, and, finally, through the royal yachts, is modified nowadays from a clumsiness to resemble more nearly the counter of the smart sailing yacht. Ample overhang at bow and stern gives both increased deck space and makes a drier ship, and at the bows this additional room is advantageous for working the anchors. As compared with the liner, the yacht has far more opportunities of showing what a graceful creature the ship really is: for she has not to rush across seas at break-neck speed, nor has she to waste her internal space with accommodation for cargo and mails. She need not clutter up her decks with clusters of derricks, but go about her easy work in a quiet and dignified manner, not forgetting to look pretty all the time. And yet she is able nowadays, by reason of her size, to carry large enough quantities of water, coals and stores to last her for lengthy voyages, independent of the shore. The question of speed is subservient to fuel-endurance, and to get her owner and his guests to their destination with the least degree of discomfort is of far greater import than to set up new steaming records. She is a good sea-boat, for she is not harassed by the limitations as to the distribution of weights which have to be studied so closely in the case of the liner. The single-screw is giving way to the twin-screw, and the triple-expansion engine is usually adopted, with its absence of any great vibration.

The steam yacht, has, however, found out the advantages of the turbine, and the first to be fitted thus was the *Emerald*, built on the Clyde in 1902 for Sir Christopher Furness. She has a Thames measurement of 797, and is propelled by three separate propellers, with their individual shafts actuated by three sets of turbine machinery. Her speed is about 16 knots on an exceptionally low coal consumption, and she showed her ability by crossing the Atlantic in the year following her birth. The recent adaptation of the Parsons turbine for moderate speeds, already discussed, will doubtless pave the way for a much more general adoption of this form of propulsion in the yacht. Otherwise speed in the steam yacht is a doubtful advantage, for with reciprocating engines there is demanded a greater amount of space which could be better used for extra cabin room. Water-ballast and bilge-keels are used to a large extent, and steel has long since proved its worth for the making of the hull as well as many other features of the ship. Now that the engines of a steam yacht have proved themselves to possess that reliability which was for a long time not conceded, the need for sails, except for steadying the ship, or, as already mentioned, for long ocean voyages, has disappeared. It is much more common to see a steam yacht given the rig as seen in the illustration on page 275, with stay-sails and try-sails, than the yards and gaff-sails of yesterday. Indeed, one might go so far as to assert that the retention of the two masts is based on appearance more than with a view to utility.

One of the most extraordinary steam yachts ever built was the *Livadia*, of which a capital model is illustrated opposite page 276. She was built in 1880 by Messrs. John Elder & Co. for the Russian Admiralty. Her unusual design was based

A STEAM YACHT TO-DAY.

By permission of "The Yachting Monthly."

on the idea of a circular floating battery invented by John Elder in the 'sixties, and reintroduced by Admiral Popoff ten years later. From a technical paper read some years ago by her builder, we gather that she was constructed in accordance with Admiral Popoff's designs to give 14 knots per hour. In case of her failing to come up to the required standard, the Russian Admiralty were to be allowed to reject her. Previous to her actual building, elaborate experiments took place with a model, and both before and after the appearance of the ship she was subject to considerable criticism, some of which, no doubt, was owing to the radical departure from accepted custom. Her builder described her as being turbot-shaped with a superstructure which contained the Imperial apartments and the accommodation for suite and crew. After her trials, she sailed from the Clyde to Brest in fine weather. Thence she crossed the Bay of Biscay, and the bad weather which had sprung up increased to a gale of exceptional violence, which also afforded the most conclusive test for her steadiness. It was found that she was wonderfully endowed with the latter virtue, and that although she had been designed for service on the Black Sea, she was able to take the seas of the Bay in a most satisfactory manner. The height of the waves was adjudged by the experts on board as being from twenty to twenty-five feet, but the receding formation of the turbot had the effect of dividing the wave against itself. In no case did the waves succeed in reaching the keels of the ship's boats hung in davits 22 feet above the load-line, and although the table was loaded with candelabra and other easily capsizable articles, the ship never lurched so as to send them moving. It is true that when she put into Ferrol, owing to the exhaustion of the crew, two of the thirty-seven cells on the external rim of the

THE RUSSIAN IMPERIAL YACHT "LIVADIA."

From the Model in the Victoria and Albert Museum.

turbot were damaged, yet this did not vitiate the general principle of her construction. She was driven by three propellers and three independent engines, and was easily handled. During the gale she only required one man at the wheel. She displaced nearly 4,000 tons, measured 285 feet in length, 153 feet in extreme width, and drew only 6½ feet.

Perhaps the one conspicuous example where the steam yacht has been designed not by a yacht architect is in the case of the steam yachts possessed by the Royalty of this land, and it is a matter of regret that some of the worst and most old-fashioned traditions should be perpetuated in what one would have expected to have been the most up-to-date and efficient steam craft afloat. There has ever been displayed in the royal steam yachts far more of the Admiralty influence of yesterday than of the modern factors at work in yacht-design. Grace and delicacy have been avoided for a kind of clumsy impressiveness, and the worst features of the eighteenth and early nineteenth centuries naval architecture are retained with a surprising obstinacy. The heavy quarters and counter, the tasteless display of external carving and gold leaf have had to make a pretence of affording what should have come spontaneously from the beauty of the vessel's own lines. The *Victoria and Albert*, launched a few years ago, is especially expressive of the defects which she ought never to have exhibited. And the latest English royal yacht which was launched in 1907, has but little character that is superior to her predecessor. This *Alexandra* will be seen at her trials in the illustration facing page 278. True, the heavy quarters have been very much modified, but in any assemblage of steam yachts or modern ocean-going steamships, she stands out less owing to her inherent beauty, than for the impression

of solidity which she conveys. The *Alexandra* has a registered tonnage of 2,157, and is driven by three turbines.

The illustration of the *Sagitta*, facing page 280, is of particular interest, for when she appeared in the summer of 1908, she was the largest steam yacht ever built on the south coast. Constructed by Messrs. Camper and Nicholson for the Duc de Valençay, she has a Thames measurement tonnage of 757, and on her trials showed a speed of 15·2 knots, which was 2·2 knots above that contracted for. Steam yacht building has more usually been the work of the northern yards. Two of her features are especially noticeable as showing a divergence from the stereotyped design of the steam yacht. Firstly, the three, and even two, masts, have gone altogether, and only one is retained, in a most unusual position, for signalling purposes. Secondly, her stem goes right away from the accepted clipper-bow-plus-bowsprit end, although the yacht-like overhanging counter is retained. In matters of this nature personal taste will enter quite independent of the demands put forward by naval architecture, but it can scarcely be said that this hybrid arrangement makes for beauty, for the nice balance which is so significant a feature of the ends of a yacht is here hardly possible. Much more acceptable is the design of the *Triad*, which, amid considerable adverse criticism for her originality, made her appearance in the summer of 1909. An interesting photograph of this novel yacht appears opposite page 280, but it conveys little idea of her size. With her two funnels, her straight stem and modified turtle-deck stern, she is a "whole-hogger" as compared with the compromise which the *Sagitta* represents. In the *Triad* the steam yacht breaks right away from accepted conditions and shows the first real approach to the contemporary ocean-going steam-

THE ROYAL YACHT "VICTORIA AND ALBERT."

THE ROYAL YACHT "ALEXANDRA."
From a Photograph. By permission of Messrs. A. & J. Inglis, Ltd.

ship. To some extent, no doubt, she exhibits some resemblance to the well-known German Imperial steam yacht, the *Hohenzollern*, but she is rather a deep-sea liner in miniature, capable of going anywhere, and performing practically any service which could be asked of her. She has been built on steamship lines by a firm which, I believe, had never previously constructed a steam yacht. Her size of 1,416 tons would alone make her interesting, but it is her business-like appearance which causes her to be especially noticeable. Her stem has come in for a good deal of criticism, some of which is doubtless justifiable, but not a little is obviously based on the fact that convention was thrown aside. It is claimed that the clipper-stem is not merely advantageous in regard to looks, but besides giving increased deck space where it is needed to work the anchors, permits of a generous amount of flare to protect the fore decks from water coming aboard. The older form also provides a useful " false " end in the case of a ship colliding, while, on the other hand, the straight stem possesses considerable merits for docking and berthing in a congested harbour.

The *Triad* measures 250 feet long, between perpendiculars, and 35 feet wide, and is equipped with twin-screw engines, which give her a speed of 16 knots. She has two double-ended boilers, and one auxiliary boiler for driving the electric installation when in port. Some of her minor features are sufficiently unusual to merit remark. Thus, for instance, the windlass on her forecastle is fitted with a special indicator which shows the amount of cable run out, and an arrangement something similar in principle to that mentioned as existing on liners is installed, whereby the engineer cannot easily make a mistake in carrying out the captain's orders from the bridge. If the engines are going ahead the captain knows this by an electric

With the capabilities of which the motor has shown itself to be possessed, the future of the steam yacht is perhaps a little uncertain. Economy would seem to indicate that the former has numerous merits in that it enables sail power to be utilised more readily, and thus may arrest the fashion which is advancing in the direction of steam. For long passages the extreme comfort which is now obtainable in the modern liner leaves no choice in the matter. To keep up a steam yacht for the usual summer season of four months is a very serious item of expenditure. If we reckon £10 per ton as the average cost—and this is the accepted estimate—it will be seen that such a yacht as the *Wakiva*, for instance, leaves but little change out of £10,000 per year, and for this expenditure most men would expect to get a very large return in the way of sport and travel. Whether or not a like proportionate return is made, at least in giving employment to thousands of shipbuilding and yacht-hands, this special branch of sea sport is deserving of the high interest with which it is regarded.

CHAPTER XI

THE BUILDING OF THE STEAMSHIP

We propose in the present chapter, now that we have seen the evolution of the steamship through all its various vicissitudes and in its special ways, to set forth within the limited space that is now left to us some general idea of the means adopted to create the great steamship from a mass of material into a sentient, moving being.

Around the building of a ship there is encircling it perhaps far more sentiment than in the activity of almost any other industry. Poets and painters have found in this a theme for their imagination not once, but many times. Making a ship is something less prosaic, a million times more romantic, than making a house, for the reason that whilst the ship, as long as she remains on the stocks, is just so many thousand tons of material, yet from the very moment when she first kisses the water she becomes a living thing, intelligent, with a character of her own, distinct and recognisable. In the whole category of man-made things there is nothing comparable to this.

Her genesis begins when the future owners resolve to have her built. Before any plans are drawn out there must first be decided the dimensions, the displacement and the general features which she is to possess, whether she is to be a slow ship, a fast ship, engaged in passenger work, cargo-carrying, on the North Atlantic route, for the East through the Suez Canal, and so on; for all these factors combine to determine

the lines on which she is to be built. Before we progress any farther, let us get into our minds the nine different types which separate the generic class of steamships. If the reader will follow the accompanying illustrations, we shall not run the risk of being obscure in our argument. Fig. 1, shows the steamship in its elementary form, just a flush-decked craft,

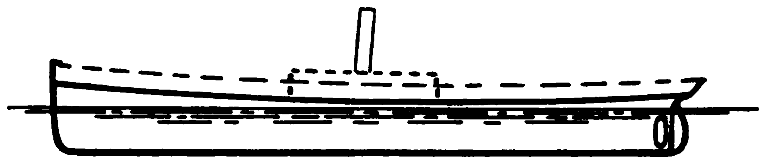


Fig. 1.—FLUSH-DECKED TYPE.

with casings for the protection of the engines as explained on an earlier page. This represents the type of which the coasting steamer illustrated opposite page 184 is an example. This casing in the diagram before us is, so to speak, an island on the deck, but presently it was so developed that it extended to the sides of the ship, and, rising up as a continuation of the

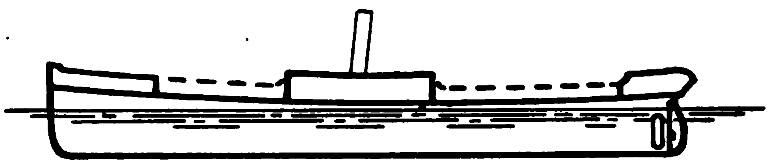


Fig. 2.—"THREE ISLAND," TYPE.

hull, became a bridge. At the same time a monkey forecastle and a short poop were added to make her the better protected against the seas. This will be seen in Fig. 2. This is known as the "three-island" type for obvious reasons. It must be understood that on either side a passage leads beneath the bridge-deck so as to allow the crew to get about the ship. But from being merely a protection for the bows of the ship,

the monkey forecastle became several feet higher, so that it could accommodate the quarters of the crew, and this "top-gallant" forecastle, as it is known, will be seen in Fig. 3. At the same time, the short poop or hood at the stern has now

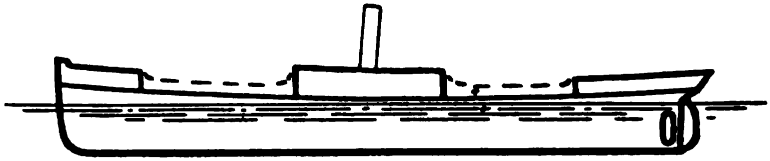


FIG. 3.—TOP-GALLANT FORECASTLE TYPE.

become lengthened into something longer. But in Fig. 4 we find the lengthened poop becoming a raised quarter-deck—that is, not a mere structure raised over the deck, but literally

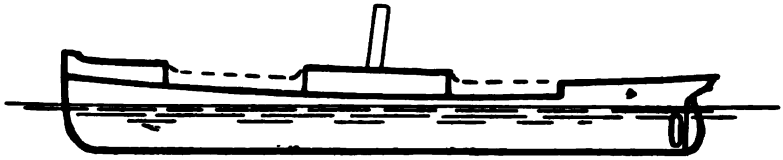


FIG. 4.—TOP-GALLANT FORECASTLE TYPE, WITH RAISED QUARTER-DECK.

a deck raised at the quarter. This raised quarter-deck was the better able to withstand the violent force of the sea when it broke over the ship. In Fig. 5 we have a still further

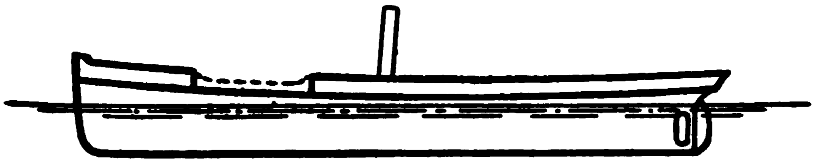


FIG. 5.—EARLY "WELL-DECK" TYPE.

development in which the topgallant forecastle is retained as before, but the long poop and the after end of the bridge are lengthened until they meet and form one long combination. This is one of the "well-deck" types, the "well" being between

the after end of the forecastle and the forward end of the bridge-deck. This well was left for the reason that it was not required for carrying cargo, because it was not desirable to load the ship forward lest she might be down at the head (which in itself would be bad), whilst at the same time it would raise the stern so that the propeller was the more likely to

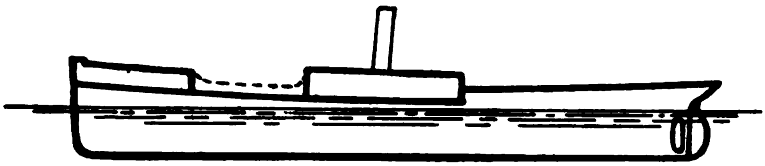


Fig. 6.—"WELL-DECK" TYPE.

race. But in the modern evolution of the steamship it is not only a question of trim and seaworthiness that have been taken into consideration, but also there are the rules and regulations which have been made with regard to the steam vessel. Now, this well-space not being reckoned in the tonnage of the ship (on which she has to pay costly dues) if kept open,

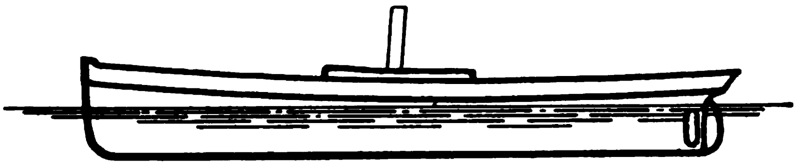


Fig. 7.—"SPAR-DECK" TYPE.

it was good and serviceable in another way. Considered from the view of seaworthiness, this well, it was claimed, would allow the prevention of the sweeping of the whole length of the ship by whatever water that broke aboard the bows (which would be the case if the well were covered up). If left open, the water could easily be allowed to run out through the scuppers. But this type in Fig. 5 is rather midway in the

transition between the "three-island" type and the shelter-deck type. The diagram in Fig. 6 is more truly a well-decker, and differs from the ship in Fig. 5, in that the one we are now considering has a raised quarter-deck instead of a poop. She has a top-gallant forecastle, a raised quarter-deck and bridge combined, and this type was largely used in the cargo ships

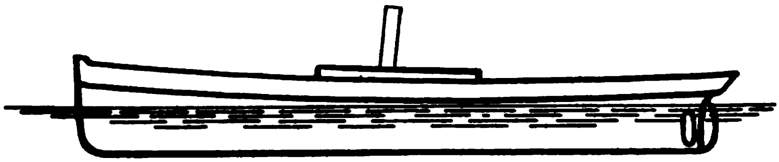


FIG. 8.—"AWNING-DECK" TYPE.

employed in crossing the Atlantic Ocean. It is now especially popular in ships engaged in the coal trade. The advantages of this raised quarter-deck are that it increases the cubic capacity of the ship, and makes up for the space wasted by the shaft tunnel. By enabling more cargo to be placed aft, it takes away the chance of the ship being trimmed by the head.

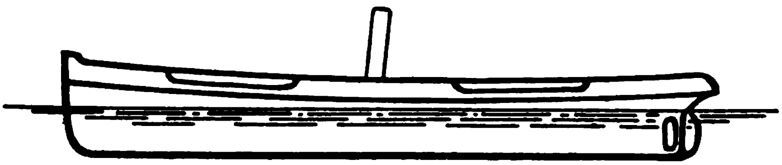


FIG. 9.—"SHADE-DECK" TYPE.

Fig. 7 shows a "spar-decker," which is the first of the three-deckers that we shall now mention. This was evolved for the purpose of carrying passengers between decks. It has a continuous upper deck of fairly heavy construction, the bridge deck, of course, being above the spar deck. In Fig. 8 we have the "awning-decker," which has a continuous deck lighter in character than the last-mentioned type, and like the

THE BUILDING OF THE "MAURETANIA."
Showing Floor and part of Frames.
From a Photograph By permission of the Cunard Steamship Co.

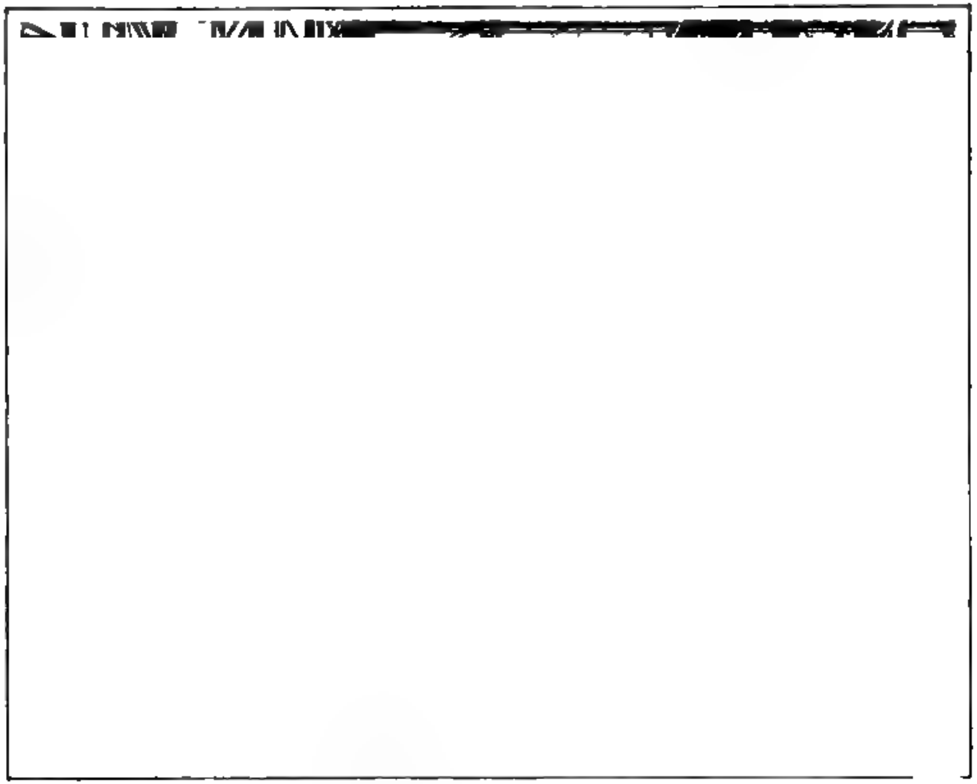
latter, the sides are completely enclosed above the main deck. Because of this lightness of construction, it is not customary to add further erections above that are of any weight. Its origin was due to the desire to provide a shelter for the ships employed in carrying Oriental pilgrims. Later on this type was retained in cargo-carriers. Finally, we have the "shade-decker" as in Fig. 9, which is provided with openings at the side for ventilation. This type is so well known to the reader from posters and photographs, that it is scarcely essential to say much. But we may remark that the lightly constructed deck fitted between the poop and forecastle is supported by round stanchions, open at the sides (as shown herewith), but sometimes closed by light plates. It is built just of sufficient strength to provide a promenade for passengers, or shelter for cattle, on the upper deck. This is still a very popular type for intermediate and large cargo steamers.

With these different types before us, we may now go on with our main subject. Having settled the question as to the type and character of the steamship to be built, the next thing is to design the midship section, which shows the general structural arrangements and scantlings of the various parts. In the drawing-office the plans are prepared, and the various sections of the ship worked out by expert draughtsmen attached to the shipbuilding yard. This necessitates the very greatest accuracy, and the building is usually specially guarded against those who might like to have an opportunity of obtaining valuable secrets. The plans having been worked out on paper, there follows the "laying off" on the floor of an immense loft, called the "mould floor," where the plans are transferred according to the exact dimensions that are to be embodied in the ship. In many cases the future owner insists on a

wooden model being submitted in the first instance, by the builder, so that a fair idea may be obtained of the hull of the proposed ship.

Each vessel is known at the shipbuilder's by a number and not by her name. The keel is the first part of her to be laid, which consists of heavy bars of iron laid on to blocks of wood called "stocks," and the line of these slants gently down to the water's edge, so that when, after many months, the time arrives for the launching of the great ship, she may slide down easily into the sea that is, for the future, to be her support. After these bars have been fastened together, then the frames or ribs are erected, the ship being built with her stern nearest to the water, and her bow inland, except in the few cases (as, for example, that of the *Great Eastern*), where a vessel, owing to her length in proportion to the width of the water-space available, has to be launched sideways. These ribs are bent pieces of steel, which have been specially curved according to the pattern already worked out. Let us now turn to the accompanying illustrations which show the steamship in course of construction. These have been specially selected in order that the reader might be able to have before him only those which are of recent date, and show ships whose names, at least, are familiar to him.

The photograph opposite page 286 represents the *Mauretania* being built on the Tyne. This striking photograph shows the floor and the double cellular bottom of the leviathan in the foreground; whilst in the background the frames of the ship have been already set up. Some idea of the enormous proportions may be obtained from the smallness of the men even in the foreground. The next illustration represents the



THE "GEORGE WASHINGTON" IN COURSE OF CONSTRUCTION.

Showing Framing from the Stern.

From a Photograph. By permission of the Norddeutscher Lloyd Co.

Norddeutscher Lloyd liner, *George Washington*, and exhibits the framing of the ship and bulkheads before the steel-plating had been put on. The photograph was taken from the stern, looking forward, and one can see already the "bulge" which is left on either side to allow for the propeller shafts. Opposite page 290 is shown the bow end of the *Berlin* (belonging to the same company) in frame, and on examining her starboard side it will be seen that already some of her lower plates have been affixed. Finally, opposite page 292 is shown one of the two mammoth White Star liners in course of construction. This picture represents the stern frame of the *Titanic* as it appeared on February 9th, 1910. No one can look at these pictures without being interested in the numerous overhead cranes, gantries and scaffolding which have to be employed in the building of the ship. The gantries, for instance, now being used at Harland and Wolff's Belfast yard are much larger than were used even for the *Celtic* and *Cedric*, and have electric cranes, for handling weights at any part of the berths where the ships are being built. Cantilever and other enormous cranes are also employed. Cranes are also now used in Germany fitted with very strong electro-magnets which hold the plates by the power of their attraction, and contribute considerably to the saving of labour.

Whilst the hull of the ship is being built, the engines are being made and put together in the erecting-shop—which also must needs have its powerful cranes—and after being duly tested, the various parts of the engines are taken to pieces again and erected eventually in the ship after she has been launched. After the frames and beams are "faired" the deck-plating is got in hand. Besides affording many advantages, such as promenades and supports for state-rooms, the

deck of a ship is like the top of a box, and gives additional strength to a ship. The illustration opposite page 292 shows the shelter deck of the Orient liner *Orsova*. The photograph was taken looking aft, on August 1st, 1908, whilst the ship was being built at Messrs. John Brown & Co.'s yard, Clydebank. The photograph is especially interesting as showing the enormous amount of material which has to go to the making of the steamship. But even still more significant is the next illustration, which shows one of the decks of the *Lusitania* whilst in course of construction. To the average man it seems to be well-nigh impossible ever to get such masses into the water.

After the plates have been all fastened by rivets to the frames, and the outside of the ship has been given a paint of conventional salmon pink, the time approaches for her to be launched. During her building the ship has been resting on the keel blocks where her centre touches, but her bilges have been supported by blocks and shores. These latter will be seen in the illustration of the *Mauretania* already considered. As the day for launching approaches, so also does the anxiety of the builders increase, for at no time in her career is the ship so seriously endangered. On the day of the launch the weight of the vessel is gradually transferred from the stocks on which she has been built, to the cradle, being lifted bodily from the keel-blocks by means of an army of men driving wedges underneath her bottom. This cradle is constructed on the launching ways, and the ship herself, being now "cradle-borne," is held in place only by a number of props called "dog-shores." At the right moment the signal is given for these to be knocked aside, and at the first symptoms of the ship in her cradle showing an inclination to glide, the bottle

BOWS OF THE "BERLIN" IN COURSE OF CONSTRUCTION. THE "BERLIN" JUST BEFORE HER LAUNCH.

From Photographs. By permission of the Norddeutscher Lloyd Co.

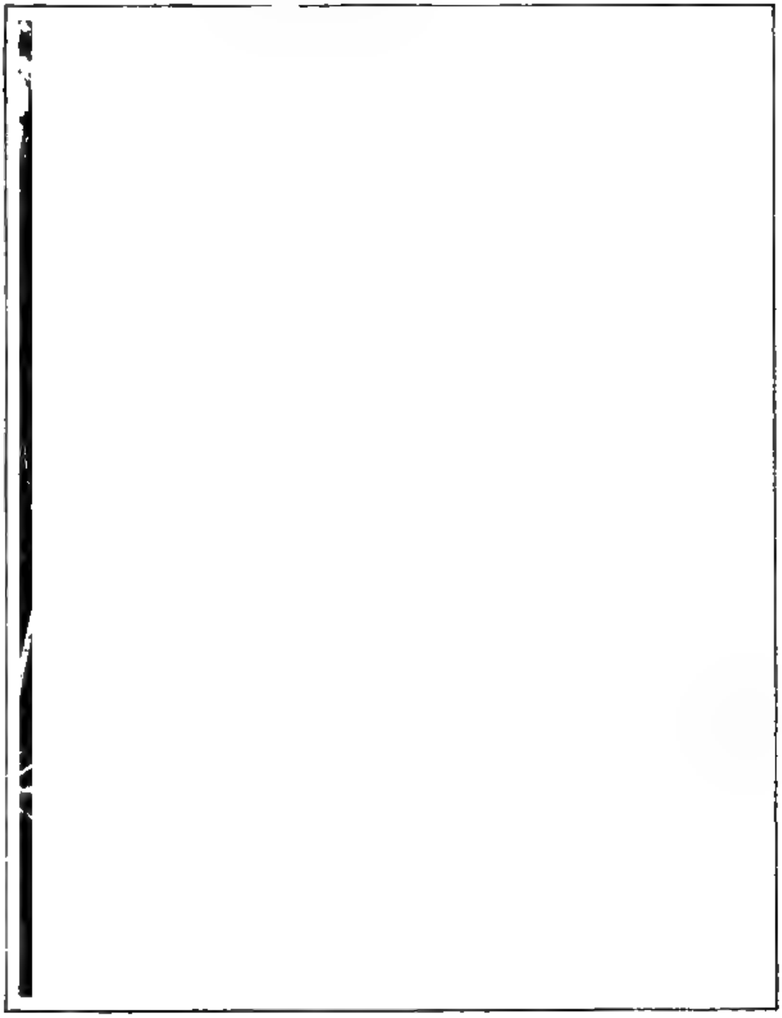
of wine is broken against her bows by the lady entrusted with so pleasant an honour. With a deep roar the ship goes down the ways, and as soon as the vessel becomes waterborne the cradle floats. The ship herself is taken in charge by a tug, whilst numerous small boats collect the various pieces of timber which are scattered over the surface of the water. Two or three days before the launch, the cradle which has been fitted temporarily in place, is taken away and smeared with Russian tallow and soft soap. The ways themselves are covered with this preparation after they have been well scraped clean. In case, however, the ship should fail to start at the critical moment after the dog-shores have been removed, it is usual now to have a hydraulic starting ram (worked by a hand-pump) under the forefoot of the ship. This will give a push sufficiently powerful to start the great creature down her short, perilous journey into the world of water which is to be her future abiding-place.

But it can readily be imagined that such a ponderous weight as this carries a good deal of impetus with it, and since in most cases the width of the water is confined, precautions have to be taken to prevent the ship running ashore the other side and doing damage to herself—perhaps smashing her rudder and propellers, or worse. Therefore, heavy anchors have been buried deep into the ground, and cables or hawsers are led from the bows and quarters and attached thereto, or else to heavy-weights composed of coils of chain, whose friction over the ground gradually stops the vessel. Not infrequently the cables break through the sudden jerk which the great ship puts on them, and the anchors tear up the slip-way. Perhaps as many as eight cables may be thus employed, each being made fast to two or three separate masses of about

five to fifteen tons, but with slack chain between so that only one at a time is started. As soon as the ship has left the ways, all the cables become taut, and they put in motion the first lot of drags. Further on, the next lot of drags receive their strain, then the third, so that no serious jerk may have been given, and the ship gradually brings up owing to the powerful friction. Lest the force of the ship going into the water should damage the rudder or the propeller, these, if they have been placed in position, are locked so as to prevent free play. After this the ship is towed round to another part of the yard where her engines are slung into her by means of powerful cranes. The upper structures are completed, masts stepped and an army of men work away to get her ready for her builders' trials. Carpenters are busy erecting her cabins, painters and decorators enliven her internal appearance, and upholsterers add the final touches of luxury to her saloons and lounges.

Turning now to the illustration facing page 290, we see the Norddeutscher Lloyd *Berlin* just before she was launched. The anchors and cables which will be dropped as soon as she has floated will be seen along her port side, and the platform for her christening is already in place. In the illustration facing page 294, which shows the launch of the Royal Mail Steam Packet Company's *Araguaya*, we have a good view afforded of the ship as she is just leaving the ways and becoming water-borne. The other illustration on the same page shows the launch of one of those turret-ships to which reference was made in an earlier chapter. In the picture of the *Berlin* will be seen the system of arranging the steel plates in the construction of the ship, and the rivets which hold them in place.

One of the most important events of the ship's life is her trial trip. Before this occurs the ship's bottom must be cleaned,



STERN FRAME OF THE "TITANIC," FEB. 9, 1910.

From a Photograph. By permission of Messrs. Ismay, Imrie & Co.

'HE SHELTER DECK OF THE "ORSOVA" IN COURSE OF CONSTRUCTION.

From a Photograph. By permission of Messrs. Anderson, Anderson & Co.

IE OF THE DECKS OF THE "LUSITANIA" IN COURSE OF CONSTRUCTION.

From a Photograph. By permission of the Cunard Steamship Co.

a foul underwater skin will deaden the speed, and give ›gether erroneous data. The weather should be favourable ›, the sea calm, and the water not too shallow to cause stance to ships of high speed, while a good steersman must at the helm so as to keep the ship on a perfectly straight rse. Around our coasts at various localities are noticeable ts erected in the ground to indicate the measured mile. obtain the correct data as to the speed of the ship, she / be given successive runs in opposite directions over this ısured mile; a continuous run at sea, the number of ›lutions being counted during that period, and a continuous past a series of stations of known distances apart, times at which these are passed being recorded as the › is abreast with them. For obtaining a "mean" speed r the measured mile, one run with the tide and one against tide supply what is required. During these trials, the ›lacement and trim of the ship should be as nearly as possible ›e for which she has been designed. But besides affording data which can only show whether or not the ship comes ›o her contract, these trials are highly valuable as affording rmation to the builder for subsequent use, in regard both ›he design of the ship herself and the amount of horse-er essential for sending her along at a required speed. The ›unt of coal consumption required is also an important ı that is discovered. This is found as follows: Let there ısed two bunkers. The first one is not to be sealed, but latter is. The former is to be drawn upon for getting steam, taking the ship out of the harbour, and generally l such time as she enters upon her trial proper. This bunker is then sealed up, and the other one unsealed, its contents alone used during the trial. After the trial

is ended, the fires being left in ordinary condition, the second bunker is again sealed up, and the first bunker drawn upon. By reckoning up the separate amounts it is quite easy afterwards to determine the exact quantity which the ship has consumed during a given number of knots in a given time. Finally, after every detail has been completed, the ship is handed over to her owners and steams away from the neighbourhood of her birth. Presently she arrives at her port, whence she will run for the next ten or twenty years, and before long she sets forth with her first load of passengers, mails and cargo on her maiden trip across the ocean. To begin with, she may not establish any new records for speed; for a ship takes time to find herself, and her officers to understand her individualities. "Know your ship" is one of the mottoes which an ambitious officer keeps ever before him, and if this is true on the navigation bridge, it is even still more true down below, where the engines will not show their full capabilities for several passages at least.

But it is not merely in ship-building, but in ship-repairing that the genius of those responsible is fully shown. Some of the achievements which have been wrought in this way are scarcely less remarkable than the work of building the ship from the beginning. It would be impossible here to go through all the historic occasions when the ship-builder's art has been so exceptionally manifested, but it is pertinent to our inquiry to mention some of the most interesting. One of the most recent was the repairing of the P. & O. *China*, after she had been on the rocks at Perim for several months. The damage was so serious that Harland and Wolff had to reconstruct her entire bottom, and the docking of her for repairs was supposed to have been a notable engineering feat.

LAUNCH OF THE "ARAGUAYA."

From a Photograph. By permission of the Royal Mail Steam Packet Co

LAUNCH OF A TURRET-SHIP.

From a Photograph. By permission of Messrs. Doxford & Sons, Sunderland.

e American liner now called the *Philadelphia*, of which we re an illustration on another page, some years ago caused ısternation by getting so far out of her course whilst proding down channel that she ran on to the dreaded Manacles, th of Falmouth. Eventually she was got off, but her damage s very great, and she had to be taken round to Belfast, ere she was practically rebuilt with an improved stern, l entirely new engines and boilers. Since then she has tinued to ply her voyages across the Atlantic without let hindrance. Most readers will also remember the *Scot*, the ious South African liner, which had a marvellous career record breaking. She was owned by the old Union Line ore they amalgamated with the Donald Currie Company. s same vessel was taken to Belfast, placed in dock, cut wo, and lengthened by building over 50 feet into her midship y, and a like operation was performed on the Hamburgerican liner, *Auguste Victoria*, at the same yard. The mans themselves in a similar way lengthened the steam- *Wittekind*, which was taken into dock at Geestemünde. without doubt the most notable case of all was that of White Star liner *Suevic*. This was a comparatively new , and was on her way home from Australia via the Cape Good Hope, and with her tonnage of 12,581, is the largest el steaming from the United Kingdom in the Australian le. She had entered the English Channel, but being out of reckoning, had the bad luck to run on to some of the gerous rocks off the Lizard, as many of my readers will btless recollect. The illustration facing page 296, which ıken from a photograph made at the time, shows this fine in her sad predicament. Happily, it was found that only fore part was ashore, and after strenuous and brilliant

work, quite two-thirds of her were cut off by means of blasting, and, not without grave peril, towed all the way up Channel to Southampton, where this greater portion was docked, and the present writer remembers the sad and sorrowful sight she presented lying alongside the quay. But the firm of Harland and Wolff, who had made her, at once set to work to build a replica of the bow portion which had been left on the Lizard rocks, and this, also after a perilous passage from Belfast to Southampton, was towed round to the dock, where the other two-thirds were awaiting. The illustrations here given show the stern portion of the *Suevic* lying in dock at Southampton, with all the breakage cleared ready for the new bow, and the replica of the forward portion just arrived from Belfast and being warped into the dock to be joined on. The two parts were effectively joined together—a wonderfully clever shipbuilding achievement—and the *Suevic* partly modern and partly old, has long since been restored to her original route as a perfectly sound and satisfactory ship.

THE "SUBVIC" ASHORE OFF THE LIZARD.

From a Photograph by Gibson & Son, Penzance

THE STERN PART OF THE "SUEVIC" AWAITING THE NEW BOW AT SOUTHAMPTON.

THE NEW BOW OF THE "SUEVIC" AT ENTRANCE TO DOCK.

From Photographs by Reginald Silk, Portsmouth.

CHAPTER XII

THE SAFETY AND LUXURY OF THE PASSENGER

In the course of our story we have treated with less consideration the aspect of luxury which, to some minds, is at once the most obvious and most striking feature of a steamship, whether yacht, liner, or excursion steamer. But since we set forth not to write a treatise on marine furniture and upholstery, but to show, step by step, how the modern steamship has come to be what she is, it was essential that we should have kept strictly to the main points of our task. Nevertheless, we should have fallen short of our duty had we omitted to give some idea of the care which is paid to make the ship take on the dual personality of hotel and ferry. It is inevitable that the ship in any age, whether of sail, steam or petrol, should be influenced by the forces at work ashore. Caligula's galleys (of which a detailed description was given in the author's "Sailing Ships: The Story of Their Development from the Earliest Times to the Present Day") were not in discord with the debasing influences at work on shore, and after due allowance has been made, it cannot be regarded as a healthy sign that modern tastes have to be catered for with such luxuriance, and that steamship companies even go so far as to advertise their graceful, stalwart ships as hotels. Not that one would wish to revert to the hardships and utter discomforts which had to be endured by the transatlantic passengers less than a hundred years ago, when the ship, after contending against waves and wind, at last came staggering into port to the intense

relief of everyone concerned. Pitching and rolling, washed fore and aft, swept from one gunwale to the other, a hell afloat for the timid and sea-sick, and a source of the gravest anxiety to her officers, she was too small to be equal to her task, too barely furnished to make life other than just tolerable.

Cooped up in bad weather below, where ventilation was sadly lacking; crowded with men, women and children going out to the New World to try their fortunes; with hard, scanty sleeping accommodation that was not even human in its comfort; gangways crowded with mean luggage, and no proper commissariat department; no refrigerating machinery, no preserved foods, but a medley of animals on deck to be killed and consumed as required—if they were not washed overboard by the unkindly Atlantic seas—it was no wonder that when at last the dragged-out agony was ended the passengers stepped ashore with firm resolutions never more to entrust themselves to the uncertain vagaries of the sea and its ships.

When Charles Dickens crossed in January of 1842, not then was the experience one of delight or anything approaching thereto. The ship on which he travelled to America was the Cunard *Britannia,* bound for Halifax and Boston with the mails. Of the other features of this early steamship we have already spoken, but some of the impressions which Dickens has left us regarding the comfort, or the want of it, on board this ship are worthy of attention by those who find cause for complaint even in the perfectly appointed travelling Atlantic "hotels" of to-day. Something of the appearance of his state-room may be seen by looking at the illustration facing this page, which is here inserted by the courtesy of the Cunard Company. "That this state-room had been specially engaged for 'Charles Dickens Esquire and Lady,'"

CHARLES DICKENS'S STATE-ROOM ON THE "BRITANNIA."

By permission of the Cunard Steamship Co.

he remarks in his "American Notes," "was rendered sufficiently clear even to my scared intellect by a very small manuscript announcing the fact, which was pinned on a very flat quilt, covering a very thin mattress, spread like a surgical plaster on a most inaccessible shelf." He speaks of his cabin as an "utterly impracticable, thoroughly hopeless, and profoundly preposterous box." What he thought of the *Britannia's* saloon is depicted for us in no sparing terms. "Before descending into the bowels of the ship," he adds, "we had passed from the deck into a long, narrow apartment, not unlike a gigantic hearse with windows in the sides; having at the upper end a melancholy stove, at which three or four chilly stewards were warming their hands; while on either side, extending down its whole dreary length, was a long, long table, over each of which a rack, fixed to the low roof, and stuck full of drinking-glasses and cruet-stands, hinted dismally at rolling seas and heavy weather." What he would have thought of the saloon and the state-rooms on the *Mauretania*, with their glaring contrast to the accommodation on the lively little *Britannia*, we need not stop to imagine. The fare in those days from Liverpool to Boston was thirty-eight guineas. Nowadays, for one-half that sum life on an Atlantic liner can be pleasant and luxurious.

As steamships became bigger, the conditions of travel became gradually more tolerable, but it was not until the influence of the first White Star *Oceanic* that a revolution was made in these matters. Quite apart from the superior qualities of her hull and engines she was more thoughtfully arranged with a view to making the passenger's life at least as comfortable as was then thought possible. Some of these improvements we have already noted in the course of our story, but it is

worth remembering that in the amelioration of the passenger's lot the White Star Line have not been in the rear. Among other items, they have to their credit the honour of having originated on board ship the placing of the saloon and passenger accommodation amidships, instead of right aft; installing electric bells, providing separate chairs in the saloon, instead of using the old-fashioned, uncomfortable high-backed forms, which were thought good enough for the ocean voyager; installing self-acting water-tight doors, supplying third-class passengers with bedding, eating and drinking utensils—for in olden days the emigrant had to provide not merely his own supply of food for the voyage, but everything he required of all sorts excepting water. It was the White Star Line which was the first to supply an elaborate system of Turkish baths for first-class passengers. But it was the *Oceanic* which was the turning-point in steamship comfort. All else that has since followed has been not a little influenced by this ship. For us to go through a detailed list of the wonderful comforts which are obtainable on board the modern passenger steamship would convey the impression of reading through an advertisement catalogue. Already the reader is in possession of some knowledge of the really wonderful equipment which is to be found on the modern ocean-going steamship. Nothing has been omitted that could well have been added. Nowadays, in spite of the extravagant waste of space which such a proceeding involves, many of the best steamships are fitted with single-berthed state-rooms, so that to be thrust into acquaintanceship with a perfect stranger is no longer essential for the whole voyage. Dickens's "preposterous box" has grown into an exceedingly comfortable apartment, and the millionaire may hire for the voyage the regal suite with bedrooms and

THE VERANDA CAFÉ OF THE "LUSITANIA."

From a Photograph. By permission of the Cunard Steamship Co.

FIRST-CLASS DINING SALOON OF THE "ADRIATIC."

From a Photograph. By permission of Messrs. Ismay, Imrie & Co.

dining-rooms, its fire-places, mirrors, sconces, bedsteads and the rest, as perfect as in the most extravagant metropolitan hotels in New York or London. With the ship's smoke rooms, veranda cafés, libraries, lounges, writing rooms, orchestras, telephones from the state-rooms, lifts from one deck to the others, a newspaper printed ready for him each morning as he comes down to breakfast with the latest American and European news transmitted to the ship over-night by wireless telegraphy; with gymnasia to keep him fit and well during the voyage, with Turkish baths, a high-class cuisine, the opportunity of dining either à la carte or table d'hôte without extra charge, whilst all the time the good ship is breaking records each voyage to get him back to mother earth as quickly as ever can be—what else is there left to the ingenuity of man to devise for the increased comfort of the much-pampered and still-grumbling passenger?

The illustration facing page 300 shows the veranda café just alluded to, which is placed high up in the sky on the *Lusitania.* Since it faces aft, no inconvenience can be felt through the speed at which the vessel is rushing through the air. But who that stood on the deck of the *Clermont* or the *Charlotte Dundas* could ever have imagined that this spacious café should form just one small section of a steamship? It is the Germans who have to some extent set the pace within recent years in steamship luxury. Anxious for the patronage of the wealthy American who was accustomed to the luxurious comforts of the best hotels, the German-American lines began to lead the way in showing that the steamship could be made as glorious within as any shore building, notwithstanding the restrictions necessarily laid upon an object that is subjected to the buffetings of wind and wave. Low ceilings gave way

to high; simplicity was conquered by ornate decoration, and this in no vulgar but an exceedingly artistic manner. Stereotyped arrangements of saloons and cabins gave way to something more in accordance with the requirements of good taste and elaborate comfort. A free use of applied art by the highest craftsmen in paintings, carvings and so on; magnificence in place of more or less ample comfort—these have been the principles which have actuated the Teutonic internal steamship arrangements ever since the 'nineties. The *Kaiser Wilhelm der Grosse* came as a sensation in this respect, and in regard to her decorations alone was the handsomest vessel in the world. The rise of German prosperity, and, therefore, the appearance of what economists demonstrate to be the immediate sequel—an instant desire to expend money in all sorts of self-indulgence—has been followed by a readiness on the part of the steamship companies to put forth the greatest material comfort that is practicable on board ship. German decorative art was in a peculiarly happy position to be able to supply all that was necessary to make a steel tank resemble a palace. Conventional dolphins and anchors were ousted by mosaics and exquisite woodwork, and a new sphere for what was original, but yet suitable, in art was opened. On such ships as the *George Washington* and the *Berlin* it is possible to regard a standard of applied art which cannot be easily equalled, still less surpassed by anything of the kind ashore. It was the German ships which were the first to break away from the convention of the long tables which divided up the saloon, and to introduce a number of round tables more in accordance with the interior of a modern restaurant. And what has been found to be best in this respect in the German ships has not been long in being copied in the rival national lines.

DINING SALOON OF THE S.Y. "LIBERTY."

GYMNASIUM OF THE S.Y. "LIBERTY."

From Photographs by W. A. Kirk & Sons, Cowes

The White Star *Adriatic,* whose saloon is shown opposite page 300, in addition to her many elements of floating luxury, has a number of other features which are notable for any steamship. Besides her lifts, she has a large Turkish bath establishment and a salt-water bath big enough to swim in. Like some of the German ships, she has also a gymnasium under the direction of a competent instructor, where one can enjoy saddle exercise, or practise rowing mechanically. There are also electric light baths and an orchestra of skilled musicians. But even these un-shippy features are not confined to the big steamers, and the illustrations opposite page 302 show respectively the gymnasium and the dining-saloon of the steam yacht *Liberty,* one of the most modern and luxurious yachts, which is owned by Mr. Pulitzer, the well-known American millionaire newspaper proprietor.

But if the luxury of human desires is catered for on shipboard, so also is personal life. Infectious disease has to be provided against, especially in the case of ships carrying emigrants. Dispensaries and hospitals are carried, with their proper equipment, and it is not so long since the world was thrilled by the announcement that on one of the swiftest mail liners a case of appendicitis manifested itself, and had to be attended to without delay. When the moment arrived the engines of the great ship were stopped in mid-Atlantic while, with great courage and admirable nerve, the surgeon performed successfully the delicate operation on the unfortunate man.

So also, in a manner entirely different, is the safety of the passengers provided for, and to an extent that is not excelled even by the fine railway systems on land. With two or three thousand souls on board, all of whom could be sent into

eternity in a few minutes, besides large quantities of cargo and precious mails, it is no wonder that not a thing is omitted that could conduce to the most efficient preservation of life and matter. From the safety valves of the engines to the elaborate apparatus on the navigating bridge, the word "safeguard" is spelled out in every single detail. Some of the more important essentials we have already spoken about, but there are others that we must not omit to mention, which find a place in the up-to-date steamship. Besides the duplicate steering gear, the elaborate system of water-tight doors, water-tight double-bottoms, powerful pumping engines, the life-boats, life-buoys, and life-belts—the first of these being placed as high as possible, so that, in case of emergency, they are as far above the water as can be—there is a fire alarm installation which leads to the bridge-house, and a highly efficient fire-extinguishing apparatus. With the introduction of electric light in place of oil lamps no doubt the dangers of fire have been minimised; but the hold and the bunkers must needs be kept well ventilated. On the German liners and on the Fall River Line steamboats electric thermostats are distributed over the principal parts of the ship and connected with an electric fire-alarm system extending to every part of the crew's quarters, which enable the extinguishing apparatus to be set working at once. Gas generated from chemicals which together possess great extinguishing virtues, is introduced into burning hold or bunker by means of an engine, so that one of the deadliest enemies of a ship at sea is not merely capable of control, but even of extinction.

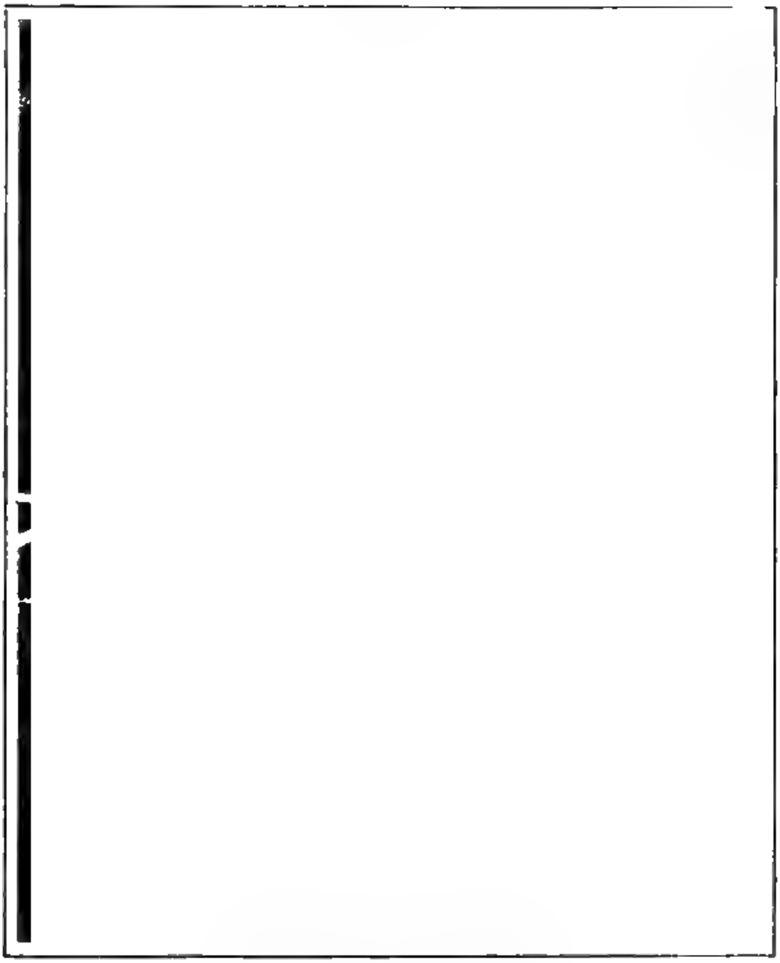
Having regard to the speed at which steamships are now compelled to traverse the oceans, it is essential that all the recognised facilities for accurate navigation are taken advantage

of in the modern liner. To prevent any possibility of mistake the engine-room telegraph is provided with a means of replying, so that the commander is able to tell whether the order has been understood. Further still, an apparatus informs him whether the order has been correctly carried out, and in the event of any of these complicated mechanisms breaking down, the speaking tube is still available. Speed indicators to register the number of revolutions made by the screws, mechanical logs, and deep-sea sounding machines, Morse signalling lamps, powerful sirens (especially useful in fog when in the vicinity of other shipping and the coast), are all now employed to give to the ship a safe and speedy passage, and to relieve the anxieties of the over-burdened modern captain.

But in two respects especially has electricity within the last few years shown itself to be of the greatest service to the ship at sea. Taking them in the reverse order of their chronology, there is first of all the system of submarine signalling so recently installed. This takes advantage of the fact that water is a conductor of sound, and with a speed more than four times quicker than air. In the case of fog overtaking a steamer approaching land, or the vicinity of a channel marked by buoys or lightships, it is possible to obtain warning by sound when sight is denied, and this at a distance of four or five miles. The submarine bell is attached to buoy or lightship, whilst the receiving apparatus is attached to the interior of the ship's hull at the bows. From there the signals are conveyed to the chart-house by means of telephones. One receiver is placed on each bow inside the plating of the ship between the keel and the water-line, so that the bell may be located on either side. A very interesting instance of the utility of submarine signalling was afforded recently in the

case of the *Kaiser Wilhelm II.*, which, owing to a dense fog, was anchored off Cherbourg. Her tender was awaiting her just outside the harbour, and sounded her submarine bell to indicate the direction to be steered in order that the big liner might make port. At a distance of no less than fifteen miles away the *Kaiser Wilhelm II.* picked up the signals by her receivers, and was enabled to find her way into the French harbour by this means alone.

Still more wonderful is the invention of wireless telegraphy, which has come to the ship as the greatest blessing and boon within recent years. With the general principles of its working the reader is, no doubt, already familiar, and the present volume need not enlarge upon them, but the accompanying illustration will be found interesting as showing the Marconi room with a telegraphist at work on a Cunarder. For a distance of 2,000 miles from Liverpool wireless connection can be maintained between the ship and the shore, whilst passing liners many miles apart are enabled to communicate with each other to their mutual benefit and safety. Whilst these pages are being printed a transatlantic wireless service has been instituted between Europe and America, and it is indisputable that the next naval war will be considerably influenced by the employment of wireless gear on board battleships, cruisers, scouts, and the bigger mosquito craft. Of the invaluable aid which already the wireless system has been to the steamship in peace we could give countless instances had we the space; but the following will suffice to show its utility within the last two or three years. On May 28th, 1907, the German liner *Kaiser Wilhelm der Grosse*, whilst on her voyage was enveloped in a dense fog and passed, without sighting, close to another steamer sailing in the same direction. The German ship,



THE MARCONI ROOM ON A CUNARD LINER.

From a Photograph. By permission of the Cunard Steamship Co

however, heard the other's sirens, and knowing that the Cunard *Caronia* was on the same track, and might run some chance of collision with the unseen vessel, the German captain sent a wireless message to the *Caronia*, and two hours and a half later received a reply from the latter which showed that the third steamer was on the Cunarder's course, and might have been a danger to her.

A clear case of the avoidance of costly salvage was afforded in April, 1910, when the Allan liner *Carthaginian*, which had left Liverpool a week earlier for St. John's, Newfoundland, was disabled at sea owing to the breaking of a piston-rod. She was able by means of her "wireless" to inform the same owners' *Hesperian* of her mishap, and the latter received the news when a hundred miles west of Malin Head, County Donegal. The *Hesperian* thereupon went to her sister's assistance, and took the ship, with her 800 emigrants on board, in tow for the Clyde. Still more interesting is the thrilling rescue which was obtained from the sinking liner *Kentucky* by the *Alamo*, which took place in February, 1909. The following statement, taken from a daily newspaper of the time, needs no embellishing, and the simple facts speak once more for the triumphant victory which the new telegraphy has obtained over some of the terrors with which the sea is inevitably associated:—

"A full statement obtained to-day from Mr. W. F. Maginnis, the operator in the *Kentucky*, who sent the wireless message received by the *Alamo*, is a most dramatic narrative. The wireless telegraphic apparatus was installed in the *Kentucky* just before her departure on a 14,000-mile cruise round Cape Horn, and to it forty-five men owe their lives.

"Early on Friday morning, during a heavy storm, the

engineer informed Mr. Maginnis that the ship was doomed. An hour later Mr. Maginnis got into wireless communication with the *Alamo*, then about ninety miles away, but not until noon was it possible for the captain to get an exact observation of his position.

" 'Half an hour before that,' says Mr. Maginnis, 'the electrician came to me and said that the water was creeping up and that the dynamo power would soon be lost. All hands were then directed to abandon all other work and devote themselves to keeping the water away from the dynamo. The turbine engine and dynamo were wrapped in canvas and power was thus preserved until the vital message was despatched.'

" When the *Alamo* at 3.30 p.m. reached the *Kentucky*, the deck of the sinking vessel was almost awash. The crew, despite the high seas, were rescued by the boats without mishap, and when they had clambered on board the *Alamo* they immediately gave three cheers for Mr. Maginnis.

" The *Kentucky* was insured for £14,000. Her seams opened wide during the storm."

CHAPTER XIII

SOME STEAMSHIP PROBLEMS

I have left till the end of the story the consideration of some of those points which, though of the highest interest to many who are anxious to know something of the intimate character of the steamship, may seem to some readers to possess a special rather than a general concern. However, now that I have shown the manifold manner in which the steamship has advanced from a thing of scorn to a vessel of admiration, and have indicated as far as possible within the limitations at my disposal the ways and means that have brought this about, we may pertinently stop to consider for a few moments some of the problems which still have to be encountered even to-day, when naval architecture and marine engineering have attained to such heights of perfection. I shall, endeavour, as, indeed, has been my aim throughout the course of this volume, to make myself perfectly clear without the employment of more technicalities than may be necessary. To the reader who may happen to form one of that large class who regard the ship, whether propelled by sails or by steam, with an admiration that verges on affection, I need offer no apology; for no one can possibly reverence the ship and, at the same time, be content to remain in ignorance about her complex nature.

Perhaps there is no feature of the steamship which is less suspected of being misunderstood than the propeller. To the average mind, its character is apparently so self-evident as

barely to require any unusual consideration. But its introduction as a means of ship-propulsion has been the cause of a good deal of miscomprehension, and has set to work the keen brains of some of the most able mathematicians in order to determine the exact relation which it bears towards the ship and the manner in which it is capable of being used for the greatest good, and with the utmost economy. Here and there in the course of the narrative I have hinted at some of these problems, but in order not to break up the continuity of the story, I deemed it best to defer until now the fuller presentation of the subject. It is not necessary to remark that the propeller's function is, by means of its revolutions, to drive the ship ahead, and to overcome the resistance which encounters the hull. Besides the skin friction, the eddy-making, and the wave-making, there is also the resistance of the air. Now let us suppose for a moment that instead of propelling itself ahead by its own engines and screws, a liner were to be taken in tow by a powerful tug-boat. It would follow then that the pull required to cause the liner to go through the water would be equal to those total entities of resistance which we have just enumerated. But let the tug be cast off, and allow the liner to start her engines and proceed by means of her propellers. The above resistance now becomes augmented by the resistance of the propellers. The reason is that the propeller causes a suction which tends to pull the ship back.

It is a striking fact that about one quarter of the propeller's work is wasted in friction, and slip. (By " slip " is meant the loss caused through the yielding of the water at the propeller, and the screw not progressing to the full extent of its pitch.) In designing the screw for a steamship, due regard must be paid

to the amount of horse-power which the engines are to generate and the speed at which the vessel is to travel, but whether the inward- or outward-turning propeller is the more efficient has not yet been satisfactorily determined by experts, though the probability would seem to be with the outward-turning screws. An instance of this was recently afforded by one of the leading firms of ship-builders in this kingdom who had been commissioned to construct a vessel 800 feet long, with a speed of between 18 and 19 knots. The owner, who was a scientist, particularly stipulated that the ship's propellers should be inward-turning, and was very positive of the advantages which would thus accrue. The builders, however, arranged the engines in such a manner that they could be driven either way with equal ease. After they had tried turning inwards, they tried outward-turning, and reversed the propellers with a decidedly satisfactory result. The same conclusion has also been arrived at by Professor W. S. Abell, who asserts that all his experience goes to prove that greater hull efficiency is obtained by outward-turning propellers. In this connection I might quote the case of the steam yacht *Niagara II.*, which was built some years ago in the United States. She was about 250 feet long, with a displacement of 2,000 tons, and her deadwood aft was not cut off. Information was obtained through two six-hour trials under similar conditions, except that her screws were interchanged from side to side, so that they were inward-turning on the first trial, and outward-turning on her second. Notwithstanding that greater horse-power was used when the inward-turning propellers were employed, yet the latter did not give the ship the same amount of speed as when they were made to turn outwards. Indeed, the speed of the inward was found to average 12·8 knots,

whereas the outward-turning screws gave an average of 14·12 knots. It is in the department of the propeller that fuller information is awaited with an enthusiasm that belongs to no other branch of naval architecture.

When we speak of a steamship as being of such a tonnage, we do not always thereby convey a correct idea as to her size, for there is a decided difference between one kind of tonnage and another. When we say a vessel displaces so much water, we know that her weight is exactly that amount of tons; but the tonnages which are given in a vessel's certificate after being surveyed are of a totally different character. The Board of Trade recognises three measurements of tonnage. First of all, comes the under-deck tonnage. The "tonnage-deck" is the second deck from below when the ship has more decks than one, and the length for the purposes of tonnage-measurement is taken along this deck. This length is divided into a number of equal parts, and the transverse sectional areas are found, deductions being allowed for the thickness of the ceilings. The gross tonnage of a ship consists of the under-deck tonnage plus the tonnage of all the closed-in spaces above the tonnage-deck, excepting the spaces fitted with machinery, wheel-house, shelter for deck passengers, galleys and w.c.'s. If the poops, bridges and forecastles are fitted with doors or some other means of closing them permanently, they have to be measured into the gross tonnage; but if they are not of a permanent character, they are exempt. Thus, the gross tonnage of a steamship might include the under-deck tonnage, the space between decks, the poop, the bridge, the forecastle, the captain's and the officers' quarters, the chart-room, the light and air space, and so on.

But the net register tonnage will be ascertained by making

certain allowed deductions, which include the space taken up for propelling power, the quarters of the crew, and of the captain, as well as the chart-room, the boatswain's store-room, and the water-ballast spaces. As instancing the curious results which are obtainable from the different measurements for reckoning tonnage, Mr. A. L. Ayre, in his "British Shipbuilding," gives the interesting comparison of a particular steamship according to her varying tonnage. Thus the ship in question has an under-deck tonnage of 550, whilst her gross tonnage worked out at 980, and her net register tonnage at 860. It is not generally known perhaps that the complicated system of arriving at the net register tonnage gives opportunity for strange and amusing effects. Owing to the difference between the actual engine-room in a steamer and the theoretical engine-room, it is not only possible to build a ship with a negative tonnage, but this has actually occurred in the case of a certain tug, and was referred to in the report of the Royal Commission on Tonnage, 1881. The present writer was recently aboard a new 20-ton yacht, in which the owner had been fortunate enough to persuade the authorities to get the measurements down so low that the net register tonnage came out at a ludicrously low figure. Internally, nothing was more conspicuous than her roominess, which was of a quite exceptional character. The vessel was a two-masted sailing craft, but supplied also with an auxiliary motor, which did not detract from the roominess of the ship, since it was placed out of the way underneath the companion ladder. However, by the time the deductions had been made for "engine-room" space, "chart-room" (which was really the comfortable and spacious main cabin), and sundry other items, the size of the yacht had theoretically shrunk from 20 tons to something almost insignificant, and

the consequence was that this bold vessel was able to escape with harbour dues as low as yachts of one quarter of her own tonnage. Not long since a humorist saw fit to write an amusing yarn, in which he depicted a certain individual who, smarting under what he believed were excessive harbour dues, determined at length to get even with the authorities, and finally had built a steam vessel rather on the lines of the screw tug than the usual steam yacht. Roominess was not the owner's objective; all he wanted was just as much space for himself as was comfortable. But he sub-divided the rest of the ship into a large space for her engines and boilers, as well as auxiliary engines to drive capstans, together with a roomy forecastle for the crew. His own cabin was clearly marked on the plan as "Captain's Cabin." Finally, after the vessel was launched, and the internal capacity of the hull, as well as the spaces occupied by the machinery and the crew, had been deducted so as to obtain the net register tonnage, it was found that instead of coming out at so much net register, the figures showed that she was *minus* 7 tons! Consequently, the owner used to protest every time he was charged with harbour dues, that instead of being called upon to pay, it was really the harbour authorities who owed him. After this, it is not surprising to learn that the name of the vessel was the *Euome*. I do not suggest for a moment that this story is anything but apocryphal, but it is sufficiently illustrative of what may occur when the tonnage measurement rules are in a state of such confusion.

It will be readily understood that it is of the utmost importance that regard be paid to the stability of the steamship, and herein is presented another of those problems which have to be taken into account and solved as easily as may be. Now,

a vessel loses a great deal of her stability when she carries loose in her hold oil in bulk, grain, rice, and such movable cargoes. A similar effect is produced, of course, by the amount of free water in her tanks. For unless these features of danger are guarded against, it follows that when the ship is inclined to one side or the other by wind or wave, the cargo will cause the ship to have a worse list, and there may be some chance of her not regaining her proper trim, and turning turtle altogether. It is not so very long since a well-known cross-channel steamer which had set out for this country disappeared during the course of her voyage, and never a man lived to say how the foundering occurred. But it was known that when she set forth a portion of her deck cargo consisted of a heavy furniture van, and this, indeed, was seen floating about at the time the disaster was thought to have occurred. The conclusion generally arrived at in the minds of the best critics was that this heavy deck cargo had caused the stability of the ship to decrease to such an extent that when the ship rolled excessively she was unable to avoid rolling right over.

We have already shown during the progress of our story how the use of tanks has gradually been employed in the ballasting of the steamship. Not merely is the double bottom used for this purpose, but, as we mentioned, tanks are placed between decks in the wings in certain ships. Although a steamship, when her double bottom tanks have been filled, becomes much stiffer and possesses a greater displacement, yet she will certainly roll more heavily, and so tend to cause heavy strains in bad weather. Many vessels possess also tanks both in the fore-peak and the after-peak, which are extremely useful for the purposes of modifying the trim of the ship. This is especially valuable when the ship is proceeding "light,"

and has not the advantage of a weighty cargo on board to keep the propeller well immersed. At the same time, supposing that the after-peak tank were utilised for the purpose of immersing the stern to a greater extent, it would also follow that the bows would be raised fairly high above the water, and in the case of a beam wind, the ship would not be easy to handle, for her head would have a strong tendency to fall off in just the same way as the man in the Canadian canoe seated at the stern finds that considerable difficulty is met with in steering his little craft with her bows out of the water, and at the mercy of every puff of wind which may blow from either side. As in other respects the ship is a compromise, so in regard to stability. She has to be stiff, or else she will roll right over in a sea-way; yet she must not be too stiff, or she will roll badly, and perhaps do herself serious harm, quite apart from being extremely unpleasant to those who happen to be aboard. Therefore, the aim nowadays is to give the ship a reasonable amount of stability, and to cause her rolling in a sea-way to be of an easy character. This is brought about by additional ballast tanks, which not only give the ship greater immersion and displacement (so causing greater stability), but by raising the centre of gravity through placing additional ballast in those 'tween-deck wing tanks that we discussed when we were considering the cantilever ships, the tendency of the vessel to roll is minimised. In fact, the combination of the double-bottom tanks and the wing tanks takes away excessive stiffness and heavy rolling, and makes the ship to behave in an easy manner in bad weather, even without cargo on board.

Then, again, since salt water is more buoyant than fresh, it will follow that when a ship passes from the sea into fresh

water, her draught will be increased, and, therefore, there will also be a decrease in the amount of freeboard above the water-line, and, consequently, the range of stability becomes less also.

Perhaps, like the propeller, the rudder also has been granted too scanty a consideration by most general readers, although its action is of the greatest interest. First of all, we must remember that the rudder is useless in the case of still water; that is to say, the ship must be going ahead or astern and not be stationary, and the speed of the vessel must be greater or less than that of the water. Thus, when a ship is riding to her anchor in a tide-way, the rudder is operative, and the vessel can be steered across the stream; but supposing she were to be steaming at the rate of 4 knots, and had with her a 4-knot tide, she would not answer her helm. We mentioned at an earlier stage that the ship when going ahead caused a column of water to follow after her. The screw itself drives a column of water astern, and it must be obvious that these masses of water must act on the rudder of the ship, and so on her steering. Thus, the column of following water causes a decrease in the pressure on the rudder, and so makes the rudder less operative. The column of water, however, which is driven astern by the propeller will cause a greater pressure on the rudder, and thus it is possible for steamships propelled by a screw to use a small rudder, and by cutting away the deadwood of the ship just forward of the rudder, the latter is less interfered with by the hull, and the steering qualities are improved. We quoted just now the expert opinions that better speed is obtained when the screws are outward turning rather than inward. The outward-turning screws also give superior steering results in the case when the screws are placed near the hull,

though when the propellers are well out, this is not so noticeable. If one desires to have a ship which shall turn quickly this characteristic is obtained by cutting away the deadwood aft, and also the ship's forefoot. An extreme instance of this is found in the case of a centre-board sailing craft, which, as anyone who has handled her knows full well, will turn round with a remarkable and surprising celerity.

There are two types of rudders fitted to steamships. These consist of the ordinary kind when the rudder is hung at its forward edge, and the balanced type which has part of its area forward of its axis. An example of the former will be found in the case of the White Star *Laurentic*, while the *Mauretania* and *Lusitania* each has a balanced rudder. Since it is necessary to the rudder that to obtain steerage effect there must be the motion of the ship through the water, or a flow of water past the rudder, so that an excess of pressure may be obtained on one side of the latter, it is possible for the steamship to possess steerage way actually before she has obtained motion; for the propeller race brings this about in an effective manner. The advent of the twin-screw system was responsible for a material increase in the turning possibilities of the ship, an advantage which was much appreciated when already the steamship had attained such enormous dimensions in regard to length. Thus, for example, supposing a twin-screw steamship wishes to turn quickly to port, she can do this by starboarding her helm, putting her port engines astern, and her starboard engines ahead. The advantage of the balanced type of rudder just mentioned is that it is easier to put over than the ordinary type, but it demands that the deadwood of the stern should be considerably cut away.

It is only comparatively recently that the full importance

which it deserves has been granted to the naval architectural experimental tank, but these interesting objects are now becoming more numerous, and yielding most valuable data on which to work. Fifty years ago naval architecture in Great Britain was certainly not on a scientific basis, and it was to France that we had to look for the leadership in these matters. But ever since the founding of the Institution of Naval Architects, and such men as Scott Russell, Sir Edward Reed and others led the way, scientific shipbuilding began to advance in this country. The results are evident in the shipbuilding history of our Royal Navy, as well as in the excellence of our splendid merchant fleets. In elucidating the many problems connected with ship architecture the experimental tank is now taking even a more prominent place than hitherto, and the recent opening of the National Experimental Tank at Bushey, where research will be carried on continuously without interference from commercial considerations, is deserving of the warmest congratulations. One of the most important tanks in the world is that owned by Messrs. John Brown and Co., Ltd., at their Clydebank works. Indeed, it may be said that no feature of this important yard is more deserving of interest. The tank is 400 feet long and 20 feet wide, with a depth of 8 to 9 feet. At the end of the tank, where the models are worked, are dry and wet docks for trimming these little ships, which are sometimes as large as 20 feet long. The latter are made of wax, carefully moulded, and their weight is automatically registered. There is an over-head rail for removing the models from one place to another, while the carriage from which the model is towed through the water runs on rails fixed on each side of the concrete walls of the tank, and is driven by electricity. At about the centre of the main tank building

there is an observation room which is used for photographic purposes. Messrs. John Brown and Co. themselves have admitted that it is owing to the valuable experiments obtained in this tank that they have been able to design ships producing the best results, whilst also exhibiting the maximum economy.

Mathematical theories and formulæ have contributed much to the development of the steamship, but there is a point reached when these are of no avail for the reason that when new problems arise that cannot be solved by former experiences and existing data, a more practical method of obtaining information must be found. It is here that the tank comes in to solve the difficulties at hand both as to the hulls of the ships themselves and the character of the propellers which are to send them through the water. Had the experimental tank been encouraged at an earlier date, no doubt certain of the errors which characterised some of the ships of the sea might have been avoided. It is not enough to build a steamship of enduring strength, and to give her the best engines of the time; it is also essential that she be designed in such a manner that her propellers forge her ahead with the minimum of resistance.

Germany and America, no less than Great Britain, are now busying themselves with the employment of the naval experimental tank, and obtain thereby so many valuable data as to make such institutions indispensable if advance in the science of naval architecture is to be something more than ephemeral. The Norddeutscher Lloyd Company had such a tank built in 1900 on the model of the one belonging to the Royal Italian Navy at Spezia, and some description may not be without interest. The tank is contained in a building 170 metres long and 8 metres wide. On either side of the

tank is a strong set of rails on which the towing carriage runs, and the building contains workshops wherein the models are constructed. The experiments are not complicated, for after the displacement of the projected ship has been decided on, several models of such a displacement are made from drawings by means of an ingenious machine. These models are made out of paraffin wax, and about 4 or 5 metres long. (A metre, it should be remembered, is the equivalent of 1·094 English yards.)

Presently, after they have been finished off, the models are towed through the tank, and their resistance is measured by a dynamometer, the automatic drum simultaneously measuring the course and time. It should be mentioned that it is after the models have been formed in sifted clay that they are cast in wax as a hollow shell, the core being made of battens, strong canvas being also employed. After the model has been subjected to the cutting machine, it is planed and scraped by hand to remove the excrescences of paraffin. The advantage which the experiments made in tanks give lies in the fact that one can thereby ascertain the resistance which the model will encounter through the water, and consequently the amount of effective horse-power that she will require. Granted that an owner desires to have built a steamship of a certain displacement, it follows that that amount of displacement is capable of being embodied in numerous different shapes; and it is part of the work of the experimental tank to determine the most suitable ratios of length, breadth and draught which shall produce the ideal ship for the purpose desired. Indeed, it may be said that it is only by means of the experiments made in tanks that any safe and reliable method can be afforded for attaining the desired end.

The model is made according to scale with a displacement proportionate to that of the steamship to be built, and the correct amount of immersion is given to the model by adding ballast in the shape of small linen bags containing shot. In order to obtain the measurements of the model's resistance in the water, it is placed under the carriage which bears the measuring instruments for indicating both the resistance of the model, and the thrusting and twisting stresses of the model screws. It should be explained that the carriage is moved by motors which derive their current from accumulators, and it is possible, by regulating the accumulators, to obtain over 400 different speeds. The advantage of this in studying the wave formation which the models set up is of the highest importance. To be able to ascertain how much resistance the model sets up at lesser and higher speeds is a great gain, and in no respect is this information more valuable than when experiments are being made with a view to high-speed torpedo boats; but as this kind of craft does not come within our present scope, we must pass on.

We may turn now from some of the more technical problems incurred by the steamship to a consideration of some of those which are of a more practical nature. It is just because the ship has in modern times taken on a dual character—become something else besides a sea-craft—that the possibilities of any accident occurring to her have increased tremendously. It is obvious that so long as you retain simplicity, there is not much chance offered for accident; but as soon as you begin to make the ship a mass of complications, then instantly there arise on every side facilities for mishap of some sort or another. Fractured shafts are happily of rare occurrence, but when they happen at all they are naturally far worse for the single-

screw ship than the vessel having two or more propellers. When a connecting rod or piston-rod breaks the matter is serious, for it is not advisable to attempt repairing the same at sea, since unless the thing is done quite effectively, there is danger of the rod giving way again, and if the piston were to be disconnected suddenly from the crank, it would smash the engine. The first time that a tail-shaft was ever repaired at sea was in October of 1900, when the chief engineer of the s.s. *Athena* successfully brought about so interesting an achievement, and a similar feat was performed about five years later on the s.s. *Milton*, so that the ship was able to steam at the rate of a hundred miles per day.

But a far more difficult and rarer task was that of the chief engineer of the s.s. *Matoppo*, who for the first time on record actually renewed the blades of the propeller at sea. This would be no mean performance in the case of fair weather, but, as it happened, there was a high sea running at the time, and the work was rendered both difficult and dangerous. One of the most tiresome accidents occurs when the steamship loses her rudder, or it becomes so much damaged as to be unserviceable. In the case of a twin-screw ship, as we have already intimated, the consequences are not necessarily serious, and ships have succeeded in making long passages steering by means of their two propellers. But in the case of a single-screw ship the carrying away of the rudder is of greater consequence, and it becomes necessary to rig up a jury rudder as well as possible. This consists in towing astern a spar which is attached to either quarter of the ship by means of hawsers.

An interesting experience is related by Commander W. H. Owen, R.N.R., who at the time of the following incident was in command of a screw steamer of about 1,200 tons. When

about 600 miles south-west of the Lizard, his ship had the misfortune to carry away her rudder. A jury rudder was rigged up in the usual way by fashioning a big steering oar out of the heaviest derrick which the ship possessed, bolting together iron plates at the outside end, and weighted below so as to keep the blade vertical. From the end steel hawsers were led in through outriggers to the steam winch. This all took time, and it was a day and a quarter before the arrangement was fixed up. When it was finally put into place, it only lasted a few minutes, for the first scend of the ship smashed the whole thing. Other means had, therefore, to be employed, and the ship was eventually steered into Falmouth, where temporary repairs were effected, the vessel then proceeding to Southampton, where a new rudder was made. Commander Owen adds that he considers the best possible arrangement, if such an accident should occur, to be as follows:—A heavy spar should be lashed to as much chain cable as the spar can sustain while yet keeping afloat, the bights of cable being allowed to hang down in lengths of about two fathoms, thus forming practically a solid sheet of iron, the bights of the cable being lashed close together by smaller chain. The contrivance is then towed astern of the ship from the quarters, sufficient scope being given to allow the spar to clear the counter as the vessel pitches or scends, the controlling being effected by means of steel hawsers attached to the other end of the spar, and led through outriggers to a steam winch.

Another kind of disaster which may overcome the steamship is that of fire. Owing to the frequency of this species of calamity, the committee of Lloyd's some seven years ago instituted a special inquiry into the matter, and after examining no fewer than 627 cases of fire on ships, it was found that

as many as 408 had occurred while the ship was in port; thus only about one-third of the instances happened while the ship was at sea. In most cases there was no evidence to show the cause of these fires, but since it was ascertained that many of the outbreaks occurred while the ship was discharging or loading cargo, it was thought that a closer supervision over the use of lights and a more stringent prevention of smoking in the holds would give more satisfactory results.

The use of water and steam as fire extinguishers is frequently abortive, and causes unnecessary damage to the cargo; but nowadays there are scientific appliances which are much more effective for extinguishing outbreaks that may occur on board ship, and these are recommended for use at the ports and docks. In 1906, the New Zealand Government appointed a Royal Commission to inquire into the causes of fires occurring on ships which carry such commodities as wool, flax and tow. Besides recommending that every ship engaged in the carrying trade of this nature should be fitted with a chemical fire-extinguishing system, the Commission reported that the cause of fire in the case of flax and tow would seem to have been usually other than that of spontaneous combustion, but the very nature of these articles makes them especially liable to fire from extraneous causes. With regard to wool, however, there was evidence for supposing that spontaneous combustion does take place.

A steamship problem of an entirely different nature is that which concerns the commissariat department. In the olden days, when travellers were accustomed to remember that they were voyaging on a ship, matters were fairly simple and straightforward; but now that the ship has become a floating hotel, and the passenger expects to live quite as well

as, if not more luxuriously than, on shore, the problem of being able not merely to feed two or three thousand people for a week or longer, without being able to touch port, but to supply most of the dainties which are only found in the best equipped land restaurant has assumed large dimensions. The days when salted meat was the staple sustenance of the sea traveller have long since gone, and to-day even the steerage passengers are catered for in a manner that is at least humane, even if it is scarcely luxurious. All this has been brought about by the influence of more comfortable living ashore, as well as by the keen competition between the rival steamship companies to hold out alluring incentives to the potential passenger. The work in connection with the culinary department has grown so enormously as to necessitate the employment of mechanical contrivances wherever possible. Thus, for instance, on some of the Atlantic liners the coffee-mills instead of being turned by hand, are driven by steam-engines and electromotors. Ingenious boiling apparatuses for eggs; machines for cutting meat, for mincing, whipping cream, straining, dish-washing and drying without the need of using towels, making bread, filtering water and many other purposes are employed, and the perfection of these minor machines is scarcely less admirable than that of the engines whose sole service consists in propelling the ship across the ocean. Some of the Norddeutscher Lloyd steamships have recently availed themselves of a new invention for carrying live fresh-water fish, so that they may come fresh to the table. This innovation was first made on board the *Kaiser Wilhelm II.* The fish-tanks are placed on the awning deck, where ocean passengers are able to have the singular experience of catching alive at sea such fresh-water fish as trout, carp, pike and tench.

The ventilation of a steamship also presents a problem that is not always capable of easy solution. Indeed, ship-ventilation presents difficulties that do not arise in the case of shore-buildings, and this is to an extent due to the fact that there is only a limited space available for the ventilating apparatus. Mechanical fans are much employed for both the stokehold and the quarters of the passengers, being driven by electric motors. The efficient ventilation of the store-rooms, which contain nowadays such quantities of perishable foods, is also effected by this means. On cattle-ships, especially in hot climates; in giving air to the holds of grain ships, and, in fact, on the steamship generally, a thoroughly capable ventilating arrangement has long since been found to be a necessity rather than a luxury. But there is a difficulty with regard to the ventilators themselves on board ship. If they are left open for the air, it is also possible for some fool or criminal to throw down a lighted match or cigarette-end, and so ignite dangerous vapour that may be below deck. After the disastrous fire on the liner *Sardinia* when off Malta, in 1909, the Board of Trade inquiry made clear the cause of the catastrophe, namely that inflammable matter had succeeded in reaching the cargo space where chemical action had generated dangerous vapours. There was only one way in which fire could have reached this dormant danger, and that was by means of the ventilators. The reader will probably recollect that the ship was carrying Moorish pilgrims at the time, and that they had been cooking food at one of their braziers, and some believe that a hot cinder was blown down a ventilator and so arrived in the hold, with the result that is now common knowledge. The possibility of such a thing occurring again, however, is now obviated by a patent weather-proof ventilator, which is

so constructed that access to the holds cannot be reached by anything else than air. Neither rain nor sea can get down, still less any inflammable matter.

Thus, one by one, problems arise to thwart the hand of man, but only to be overcome by the latter through patience and the knowledge which comes after much thought and actual experience. Not merely in seaworthiness, nor in the matter of speed, has the steamship reached what even the most blasé must call the limit, but the same enterprising spirit which has brought this about has also provided that comfort is also of an importance that demands the most detailed attention. Whether in return for all this care and trouble the passenger is proportionately grateful is another question altogether.

INDEX

Aaron Manby, the, 132
A. L. Shotwell, the, 260
Abell, Prof. W. S., 311
Aberdeen Line, 216
Acadia, the, 107
Admiral de Ruyter, the, 237
Admiralty, the, mail service and, 105, 110, 114; use of bulkheads and, 156; and mail service, 224; and mails to Channel Islands, 227
Adriatic, the, 179, 206–7, 208, 303
African Steamship Co., 216
Alamo, the, 307
Alexandra, the, 277
Allan Line: introduction of turbine into Atlantic service, 190; foundation of, 216
Allen, John, method of propelling boats by, 27; and lifeboats, 254
America, early steamboats of, 44; steam navigation in, 60, 63; development of steam engine in, 88; river steamers of, 258; lake steamers of, 264
American Line, 165, 173, 220
Amerika, the, 207
Anchor Line, 216, 220
Anglia, the, 222
Arabic, the, 179
Araguaya, the, 292
Archimedes, steam power and, 19
Archimedes, the, 120–1, 123, 124
Argyle, the, 84
Arizona, the, 155, 156
Armstrong, Mitchell & Co., 243
Asturias, the, 229
Atalanta, the, 228
Athena, the, 323
Atlantic, steamships on, 91, 96; the *Sirius*, 96–7; the *Great Western*, 97; early fares, 100; Liverpool—New York route, 101; the *Royal William*, 101–2; the *British Queen*, 102; inauguration of mail service, 105–7; the *Britannia*, 107–9; Collins Line, 118; the *Robert F. Stockton*, 119; *Scotia's* record, 129; Inman Line competition, 148; Cunard competition, 149; records of *City of Paris*, *Russia*, and *City of Brussels*, 149; White Star competition, 154–5; *Britannic's* record, 155; *City of Berlin's* record, 155; Guion Line competition, 155; *Servia's* record, 157; records of *Umbria* and *Etruria*, 159; competition of 'eighties, 165; *Majestic's* and *Teutonic's* records, 169; *Lucania's* and *Campania's* records, 171; German competition, 173, 179, 180; *Kaiser Wilhelm II.'s* record, 180; Allan Line and turbines, 190; records of *Mauretania* and *Lusitania*, 204; Royal Line, 217
Atlantic Transport Line, 220
Atmospheric engine, invention by Papin of, 22
Auguste Victoria, the, 295
Austral, the, 162
Australia, inauguration of steam service to, 116
Australian Royal Mail Steam Navigation Co., 131
"Awning-deck" type, 286
Ayre, A. L.: "British Shipbuilding," 313

Baird, Charles, 86
"Balanced" rudders, 318

INDEX

Ballast, questions of, 315
Ballin, Herr, 212
Balmoral Castle, the, 219
Baltic, the, 167, 193, 194, 207
Barlow, Joel, association with Fulton, 49
Beam engine, 36; development and adaptation, 87; of American river boats, 262;
Bell, Henry, and Symington, 55; experiments with paddles: the *Comet*, 78
Ben-my-Chree, the, 230
Berlin, the, 209, 289, 292, 302
Bernoulli, Daniel, 33
Bessemer, the, 225
Bibby Line, 215
Bilge-keels, of *Campania* and *Lucania*, 171; of *Mauretania* and *Lusitania*, 200
Blackcock, the, 235–6, 237
Boiler, evolution of, 133; distilled water and, 136, 167; "Scotch" type, 151
Booth Line, 216
"Boss" of screw shaft, 210
Boulton and Watt, 35, 43, 59, 60, 75, 84, 88, 89, 94, 95
Boulton, Matthew, association with Watt, 35
Bourne, William, "devises" for propelling boats, 15
Bovic, the, 220
"Box" boiler, 133
Branca, Giovanni, discovery of principle of turbine by, 20, 184
Bridge deck, evolution of, 162, 283; in tugs, 235, 237
Britannia, the, 107, 108–9, 298
Britannia, the (P. & O.), 163
Britannic, the, 153, 154
British and Foreign Steam Navigation Co., 227
British and North American Royal Mail Steam Packet Co., 107
British East India Co., 216
British Queen, the, 97, 102, 103
British Queen Steam Navigation Co., 97
"British shipbuilding," by A. L. Ayre, 313
Brown, John, & Co., 319
Brunel: the *Great Western*, 97; the *Great Britain*, 123; the *Victoria*, 131; *Great Eastern*, 139
"Bucket" dredger, 239
Building of ships, 282, *et seq.*
Bulkheads, of *Scotia*, 129, 130; of *Great Eastern*, 143; of *Arizona*, 155; Admiralty and, 155–6; of *New York* and *Philadelphia*, 166; of *George Washington*, 208; of *Laurentic*, 210; of oil-tankers, 244; of *Commonwealth*, 263
Bulwarks, disappearance of, 152
Buenos Ayrean, the, 150
Burns, George, 106
Bushey, national experimental tank at, 319
Byrne, St. Clair, 270

Cables, submarine, laying of, 242–3
Caird & Co., 218
Calais-Douvres, the, 225, 226
Caledonia, the, 84, 107
Caligula's galleys, 194, 297
Cambria, the, 222, 225
Campania, the, 159, 170, 171, 172, 174, 175, 177
Camper and Nicholson, 278
Canadian Northern Railway Co., ships of, 217
Canadian Pacific Railway, ships of, 220
Candia, the, 134, 135, 136
Cantilever-framed ships, 249
Car of Neptune, the, 76
Cargo, dangerous, 243, 246
Carmania, the, 187, 191, 192
Caronia, the, 191, 192, 306
Carthaginian, the, 307
Castalia, the, 225, 226
Castle Mail Packets Co., 216
Cedric, the, 178, 179, 289

Celtic, the, 147, 178, 289
Cevic, the, 220
Channel Islands, boat services to, 227
Charlotte Dundas, the, 46–8, 55, 78, 301
Chester and Holyhead Railway Co., ships of, 222
China, the, 150, 294
"Chronological History of the Origin and Development of Steam Navigation," by Admiral Preble, 30
Churchyard, Mr., and mail contract, 224
City Line, 216
City of Berlin, the, 155
City of Brussels, the, 149, 154
City of Cleveland, the, 264
City of Dublin Steam Packet Co., 101, 124
City of Edinburgh, the, 93
City of Glasgow, the, 147
City of Manchester, the, 147
City of New York, the, 165
City of Paris (1), the, 148, 149, 152, 153, 176
City of Paris (2), the (Inman), 165, 168, 178
City of Philadelphia, the, 148
City of Rome, the, 165, 236
Clarence, the, 267
Clermont, the, 48, 60, 63; engines of, 69; original drawings for, 69; first trials of, 69; trip on Hudson, 70; at Hudson-Fulton celebrations, 70; alteration of, 73; disappearance of, 76; engines of, 88; steering methods of, 89; boilers of, 133, 137, 238, 261, 301
Clydebank Works, 319
Clyde, the, 110
"Clyde Passenger Steamer: Its Rise and Progress during the Nineteenth Century," by Capt. J. Williamson, 78
Coal consumption, tests for, 293
"Coffin-brigs," 105
Collier, improvements on, 250
Collins Line, 118, 173, 216
Columbia, the, 107
Comet, the (1), 48; building, 78; engines, 79; commercial failure, 80; wreck of, 82; boiler of, 133
Comet, the, (2), 82
Commonwealth, the, 261, 262
Compagnie Transatlantique, 212
Compound engine, principle of, 117
Condenser, invention of, 135; surface, 136, 167; of *Great Eastern*, 141
Continental routes, 223
Copenhagen, the, 229
Cornelia, the, 269
Cranes used in shipbuilding, 289
Cross-channel service, institution of, 82, 84, 221, *et seq.*
Cunard Company: foundation of, 106; early ships of, 107; monopoly of Atlantic, 118; adoption of iron, and screw propellers, 128, 145; Atlantic competition, 149, 156, 170, 178; use of steel, 156; use of turbines, 191; agreement with Government as to *Mauretania* and *Lusitania*, 196; new ships, 212; Mediterranean service, 220
Cunard, Samuel, and *Royal William*, 105; association with Robert Napier, 106; tender for steam carriage for mails, 106; British and North American Royal Mail Steam Packet Co., 107; correspondence with Ross and Primrose, 108

De Caus, Solomon, 7, 9, 20
Decks, evolution of, 149, 152; "turtle," 153, 158, 168, 172; "bridge," 162; of *Lucania*, 172; of *Oceanic*, 177; of *Carmania*, 191; of *George Washington*, 208; of *Balmoral Castle*, 219; of turret-

ships, 246; of American river boats, 259; of lake steamers, 264; of yachts, 272; types of, 283–287; construction of in liners, 290
Deck-cargo, dangers of, 315
Deck tonnage, 312
Decoration in modern liner, 302
De Garray, Blasco, early experiments of, 14
De Jouffroy, Marquis, as first inventor of steamship, 8; experiments with Watt engine, 33, 40; second steamboat of, 41, 55
De Laval, Dr. Gustav, invention of turbine, 184
Denny, William, 81
Desblanc, Fulton and, 56; experiments by, 59
Deutschland, the, 198, 207, 213
Dickens, Charles, on Atlantic passage, 298–9, 300
"Displacement," definition of, 146
Donaldson Line, 216
Dover-Calais route, first steamer on, 223
Dredgers, variety of, 239
Dredging of harbours, 211–2
Dromedary, the, 239, 261
Dublin Steam Packet Co., 221
Dundonald, Earl of, 133

Eastern Navigation Co., 139
Eclipse, the, 259, 260
Edinburgh Castle, the, 219
Edmund Moran, the, 237
Elbe, the, 174
Elder & Co., John, 160, 274
Electric light, first use of on liners, 155
Electricity, modern service of, 305
Elizabeth, the, 86
Ellerman Line, 216
Emperor of Russia, the, 86
Empire, the, 261
Empress, the, 226
Empress of Britain, the, 220
English Channel, first steamer crossing, 82
Enterprise, the, 94
Eothen, the, 269
Ericsson, John, screw propeller of, 119
Etruria, the, 158–9, 161, 165, 212, 235
Europa, the, 212–3
Experimental tank, naval architectural, 318; national at Bushey, 319; at Clydebank Works, 319; Norddeutscher Lloyd, 320; Italian, 320
Express, the, 225

Fairy, H.M.S., 210
Falcon, the, 94
Fall River Line, the, 262, 304
Falmouth as mail port, 111
Faraday, the, 243
Field, Joshua, 101
Fire, methods of extinguishing, 304; causes of, 325; extinguishers, 325
Fire Fly (1812), 76
Fire King, the, 268
Fire Queens, the, 268
Fishguard, dredging at, 239
Fish-tanks on liners, 326
Fitch, John, association with Rumsey, 44; first steamboat, 44–5; dispute with Fulton, 46
Flush-decked steamship, 137, 283
Fly-wheel, invention by Watt, 38
Forth, the, 111
Francis B. Ogden, the, 119
Francis Smith, the, 120, 123
Franconia, the, 212
Fulton, Robert, centenary, 7; and Desblanc, 8; and Rumsey, 44; *versus* Fitch, 46; birth: visit to France: "plunging-boat": association with Livingston, 48–9; experiments in Paris, 49; loss of first boat, 52; second boat, 54; the *Clermont*, 60;

building of *Clermont*, 63; experiments on paddle-resistance, 65; construction of *Clermont*, 69; first voyage of *Clermont*, 70; betrothal, 71; death, 76; Bell's association with, 78; schemes for India and Russia, 85; experiments with model, 120, 259, 261

Galloway, Elijah, 101
Gamecock, the, 235
General Steam Navigation Co., founding of, 93, 216, 223, 224
George Washington, the, 208, 213, 289, 301
Georgic, the, 219
German ship-building, growth of, 173
Germanic, the, 154
Girard, Capt. G. B., 235
Glass, use of for sidelights, 153
Glowworm, the, 268
"Grasshopper" engine, 79
Great Britain, the, 123, 124, 135, 138
Great Eastern, the, building of, 138; launch of, 140; engines of, 141; speed of, 142; construction of, 143; comparison with modern ships, 144, 157, 173, 176, 179, 180, 192, 196, 242, 288
Great Eastern Railway, boats of, 229
Great Lake steamers, 264
Great Western, the, 97, 99, 100, 102, 103, 105, 106, 123, 138, 148
Great Western Railway, steamers of, 98, 123; Channel service of, 228; passenger tender, 238
Griffiths, Robert, 210
"Guards" of American paddle-boats, 261, 264
Guericke, Otto von, discovery of vacuum, 20
Guest, Montague: "History of Royal Yacht Squadron," 267
Guion Line, 155, 156, 212

Hall, Samuel, 136
Hamburg-American Line, 207, 212
Harbour-deck of turret-ship, 246; of trunk-deck steamer, 248
Harbours, depth of, 211; dredging of, 239
Harland, Sir Edward, 152, 168
Harland and Wolff, 151, 207, 209, 211, 212, 217, 289, 294, 295
Harrison Line, 216
Harwich-Hook of Holland route, 229
Helen McGregor, the, 128
Helm, developments of, 90
Hero (130 B.C.), application of steam power by, 19
Hesperian, the, 307
Hibernia, the, 222
Himalaya, the, 134
Hindostan, the, 114
"History of American Steam Navigation," by J. H. Morrison, 44
"Hogging," 98, 102
Hohenzollern, the, 279
Holt Line, 220
Holyhead as port, 221
Holyhead–Kingstown service, 222
Horse-power, definition of, 39; in relation to speed, 67
Houlder Brothers, 216
Howden draught system, 209
Hudson, the, steamers of, 261
Hudson-Fulton celebrations, 69, 70
Hulls, Jonathan, inventions of, 29, *et seq.*; 258

Ice-breakers, 250–1
India, first steamship voyage to, 94; first steamships to, 114
Inez Clarke, 258
Inland, the, 245, 248
Inman Line, iron steamers of, 147; Atlantic competition, 148, 165
Institution of Naval Architects, 319
"Intermediate" ships, 178, 220
Ioland, the, 280
Irish Channel, steam service across, 221, *et seq.*

Iron, first use of in masts, 122; first steamboat of, 124; general use of, 145; advantages of, 146
Isle of Man Steam Packet Co., 230
Ismay, Mr. T. H., 151
Ivernia, the, 167, 178, 220

James Watt, the, 77, 93
Jenny Lind, the, 268
John Bowes, the, 242
Jones, Sir Alfred, 216

Kaiser Wilhelm der Grosse, 174, 175, 177, 178, 179, 180, 198, 207, 302, 306
Kaiser Wilhelm II., the, 149, 162, 179, 180, 198, 207, 209, 306, 326
Kentucky, the, 107
Kronprinzessin Victoria, the, 236

Lady Lansdowne, the, 124
Laird, John, 124
Lane, Thomas, association with Fulton, 85
Launch, conduct of a, 290
Laura, the, 229
Laurentic, the, 209, 211, 318
"Leibnizens und Huygens Briefwechsel mit Papin," by Dr. Ernst Gerland, 23
Leinster, the, 222
Leviathan, the, 240
Liberty, the, 280, 303
"Life of Robert Napier," by James Napier, 78
Lifeboats, 254–6
Lifeboats, steam, application of Allen's principles to, 28
Lightning, the, first mail steamer, 93
Liner, inauguration of, 104, *et seq.*; transition state of, 145; luxuries of, 300–4; navigation safeguards of, 305; ventilation problems, 327; commissariat difficulties of, 385
"Link-motion gear," 142
Livadia, the, 274, 276
Liverpool, first steamship in, 83; depth of water at, 239
Liverpool Screw Towing and Lighterage Co., 235
Livingston, Robert R., association with Fulton, 48–9, 60
Lloyd's, committee of inquiry into fires, 324
Lobnitz & Co., Messrs., 239
London, the, 162
London, Brighton and South Coast Railway, boats of, 227
London, Chatham and Dover Railway, boats of, 223, 224, 226
London and North Western Railway Co., ships of, 222
London and South Western Railway, Channel service of, 228, 229
Lucania, the 159, 170, 171, 172, 174, 175, 177, 212
Lusitania, the (Cunard), 8, 60, 103, 107, 138, 146, 173, 180, 192, 194–206, 212, 213, 239, 301, 318
Lusitania, the (Orient Line), 161
Lyons, the, 227
Lysistrata, the, 280

Macedonia, the, 218
MacIver, David, 106
Magnetic, the, 193
Mails, carriage of Continental, 224
Mail service to Channel Islands, 227, 228
Mail steamer, the first, 93
Mail steamers, first tender for, 105; early Cunard, 107; Royal Mail Steam Packet Co.'s first contract and ships, 110–11
Majestic, the, 149, 168, 178, 179, 194
Maloja, the, 218
Malwa, the, 218
Manby, Aaron, and first iron steamboat, 124, 132
Mantua, the, 218
Marconi system, installation on *Campania* and *Lucania*, 171

Marjory, the, 84
Marmora, the, 218
Mathesius, steam power and, 19
Matoppo, the, 323
Matthews, Capt. B. E., 148
Maudslay, Joseph, 132; *Great Western* engines, 100
Mauretania, the, 8, 60, 103, 107, 138, 144, 146, 151, 153, 173, 192, 193, 194, 206, 208, 211, 212, 213, 230, 236, 238, 239, 288, 299, 318
Mechanical propulsion of boats, early forms of, 10, 13, 14, 15, 16, 20, 22; Earl Stanhope's scheme, 57; Elijah Ormsbee's scheme, 57
Medina, the, 218
Medway, the, 242
Megantic, the, 209
"Memorials of James Watt," by Williamson, 83
Menai, the, 223
Menai, the (S. Y.), 268
Mersey Docks and Harbour Board, 240, 241
Miller, Patrick, first paddle-boat by, 42; steamboats by, 43
Milton, the, 323
Minnehaha, the, 220
Mississippi, Fulton's scheme for the, 76; steamboats of, 258, 259, 260
Moldavia, the, 218
Monarch, the, 242
Mongolia, the, 218
Monitoria, the, 247
Monkey forecastle, 283–4
Mooltan, the, 118, 218
Morea, the, 218
Morrison, J. H.: "History of American Steam Navigation," 44
"Mould floor," shipbuilders', 287
Munich, the, 229
Murdoch, William, 132

Napier, Charles, application of paddle-wheels by, 14; and first iron steamboat, 124
Napier, David, experiments in resistance, 81; the *Rob Roy*, 81; and cross-channel packets, 220; and *Comet*, 79; condenser and, 136
Napier, James: "Life of Robert Napier," 78
Napier, Robert, engines for *British Queen*, 102; and Samuel Cunard, 106, 107; and steam yachts, 267
Natchez, the, 259, 261
National Line, 151, 212
Naval Architects, Institution of, 319
Navigation, modern safeguards, 305
Nelson Line, 220
Newcomen, Thomas, steam engine of, 25–7; improvement of by Watt, 35, 135
New England Navigation Co., 262
Newhaven–Dieppe route, 227
New York, the, 165, 220
New York harbour, dredging of, 212; tugs of, 237
New Zealand Commission on causes of fire, 325
Niagara II., the, 311
Noah's Ark, compared with *Baltic*, 193
Norddeutscher Lloyd, growth of, 174, 208, 209
North German Lloyd, 174, 216, 220
Northern Yacht Club, and steam yachts, 267
Notre Dame des Dunes, the, 253
Novelty, the, 121

Ocean, the (tug), 236
Oceanic, the (1), 138, 151–5, 168, 299, 300
Oceanic, the (2), 176, 179, 180, 215
Ohio, steamers of the, 258
Oil-lamps, first use of, 153
"Oil-tanker," the, 243
Olympic, the, 207, 211
Ophir, the, 169
Oregon, the, 156
Orient, the, 161, 162

Orient Line, foundation of, 161
Ormsbee, Elijah, 57, 59
Orontes, the, 252
Oscillating engine, principle of, 132; of *Great Eastern*, 141; of *Leinster*, 222
"Overland" route, 115
Owen, Commander W. H., 323

Pacific, the, 133
Pacific Steam Navigation Co., establishment of, 113, 161, 151
Paddle-wheels, Roman use of, 13; on frigate *Galatea*, 14; early application of, 16–17; early forms of, 22; de Jouffroy's, 41; Patrick Miller's, 42; Symington's, 43; Fitch's, 45; of *Charlotte Dundas*, 47; Fulton's, 49; Fulton's experiments on resistance of, 65; of *Clermont*, 72–4; Bell's experiments, 78; of *Comet*, 79; on early steamboats, 86; of *Prinzessin Charlotte*, 89; of *Savannah*, 91; "cycloidal" type of *Great Western*, 100; of *Britannia*, 109; of *Scotia*, 129, 130; in tugs, 239; of *Great Eastern*, 141; stern, 258; American "guard" system, 261; of *Commonwealth*, 263; first fitted to yacht, 268
Panama Canal, 114
Pancirolli, Guido: "History of Many Memorable Things Lost, &c.," 16
Papin, Denis, 7, 9, 10; invention of steam engine, 21; first steamboat, 22; safety valve of, 23; correspondence with Leibnitz, 23–4
Paragon, the, 76
Paris, the, 166
Parsons, Hon. C. A., invention of turbine, 184
Parsons turbine for yachts, 274
Peluse, the, 239, 240
Peninsular and Oriental Co., establishment and first ships of, 114; "overland" route to India, 115; Australian service; influence of Suez Canal on, 117; the *Mooltan*, 118, 161, 163; and Lund Line, 216; recent ships of, 218
Penn, John, 133
Périer, experiment with a Watt engine, 33, 40; association with Fulton, 50, 54, 56
Persia, the, 129, 147
Philadelphia, the, 165, 220, 295
Phœbus, the, 244
Phœnix, the, 76
Pirrie, Lord, 217
"Plunging-boat," Fulton's, 48
Pool Zee, the, 236
Popoff, Admiral, 276
Post Office mail packets, 224
Preble, Admiral, on Hulls' experiments, 30; on American and English engines, 88
Prince Robert of Hesse, paddle-wheel boat of, 22
Princess Mary, the, 224
Princess Maud, the, 224
Prinzessin Charlotte, the, 89
Priscilla, the, 262
Propeller, problems connected with, 309–10; inward *v.* outward turning, 311; effect on steering, 317
Providence, the, 262
Pulitzer, Mr., 303
Puritan, the, 262

Quadruple-expansion engines, 166, 178
Queen, the, 230
Queen Victoria, yachts in honour of, 268

Randolph Elder & Co., 116
Reciprocating engine, Watt's invention of "double action" for, 38; difficulties of, 209; of *Laurentic*, 210

Red Star Line, 150
Reed, Sir Edward, 319
Rennie & Sons, Messrs. J. T., 216
Repairs, curious, 294–6, 323
Resistance, Fulton's experiments, 65; recent experiments, 66; varieties of, 67; D. Napier's experiments in, 81; John Scott Russell and, 130–1; speed and, 176; experiments in, 321–2
Richmond, the, 76
Robert G. Lee, the, 261
Robert F. Stockton, the, 119 124
Rob Roy, the, 81, 221, 223, 224
Rogers, Moses, 91
Roode Zee, the, 236
Ropner & Sons, Messrs., 248
Rotary engine, Watt's, 37
Royal Commission on Tonnage, 313
Royal Edward, the, 217
Royal George, the, 217
Royal Line, 217, 220
Royal Mail Steam Packet Co., first contract for mails, 110; the *Teviot* and *Clyde*, 110–11; *Forth* and *Thames*, launch of, 111; removal to Southampton; extension to South America, 112; the *Trent*, 113
Royal William, the (American), 95, 103, 105, 221
Royal William, the (2) (1838), 101
Royal yachts, 277–8
Royal Yacht Squadron and steam yachts, 266–9
Rubie, John, 89
Ruby, the, engines of, 94
Rudder, balanced type of, 201; bow-, 231; of "bucket" dredgers, 240; action of, 317; types of, 318; loss of, 323
Rumsey, James, method of propelling boats of, 28; experiments by; association with Fulton and Fitch, 44: 254
Russia, introduction of steamships into, 85
Russia, the, 149, 150
Russell, Scott, on Hulls' experiments, 31; and "resistance," 130–1, 137; and *Great Eastern*, 139, 319

St. Paul, the, 220
St. Petersburg, the, 229
St. Louis, the, 220
Safety-valve, discovery by Papin of, 23
"Sagging," 99, 102
Sagitta, the, 278
Sailing ship, limitations of, 5
Saloon, position of, 152; fittings of, 153; of modern liners, 300, 302
Sardinia, the, 327
Savannah, the, 91
Savery, Thomas, inventions of, 24–5; "horse-power" calculations of, 39
Saxonia, the, 178, 220
Scot, the, 295
"Scotch" boiler, 151
Scotia, the, 129
Scotia, the (Holyhead), 222
Screw, first use of by J. Stevens, 63
"Screw-port," introduction of, 169; of *Mauretania*, 201
Screw propeller, development of, 119; Ericsson's, 119; Francis Smith's, 120; effect on ship-designing, 122; "slip" and "pitch" of, 122–3; "racing," 129; of *Victoria*, 131; spur-gearing for shafts, 135; of *Great Eastern*, 142; twin-screws, 165; "overlapping" of twins, 169; of *Ophir*, 169; of *Campania*, 171; in relation to turbine, 190; of *Mauretania*, 201, 203; of *Laurentic*, 210; adaptation to lifeboats and fire-floats, 256; for yacht, 269
Sea Serpent, the, 268
Servia, the, 150, 156

Seventeenth century, scientific discoveries of, 20
"Shade-decker" type, 287
Shaft, fractured, 323
Ship architecture, problems of, 319
Side-lever engine, development of, 88; of *Britannia*, 109; improvements of, 127; of *Helen McGregor*, 128; of *Scotia*, 130; first applied to yachts, 268
Silverlip, the, 245
Silvertown, the, 243
Sir Francis Drake, the, 238
Sirius, the, 96, 97, 100, 101, 105, 193
Slavonia, the, 212
"Slip" of propeller, 122, 310
Smit & Co., Messrs. L., 236
Smith, Assheton, and steam yachts, 266–8
Smith, Francis, screw-propeller of, 120
Somerset, Edward (*see* Worcester, Marquis of)
South America, establishment of Royal Mail service to, 112
South Eastern Railway, 223; boats of, 224
Southampton, as headquarters of Royal Mail Co., 112; –Havre route, 227; dredging at, 239
South of England Steam Navigation Co., 227
South Western Steam Packet Co., 228
"Spar-deck" type, 285
Speed, appreciation of, 181, 213
Sponsons, arrangement of, 261
Spur-gearing, 135
Stability, problems of, 315–6
Stanhope, Earl of, Fulton and, 56; experiments of, 57, 59
Steam power, problems concerning, 3; evolution of, 18; application of by Hero, Archimedes and Mathesius, 19; Solomon de Caus' and Giovanni Branca's discoveries, 20; Denis Papin's invention, 21–4; Savery's inventions, 24–5; Newcomen's engine, 25–7; Jonathan Hulls' tow-boats, 29; Watt's engine, 34–8; Symington's engine, 43; Fitch's development in America, 44–5; improvements on *Charlotte Dundas*, 47; Fulton's experiments, 49, *et seq.*; the Stevens's boats, 63; development in America, 76; "Grasshopper" type of engine, 79; side-beam engine, 88; American and English engines, 88; improvements in engines, 94; the compound engine, 116; oscillating engine, 132; vertical trunk engine, 134; condenser, 135, 136, 167; steering gear, 144; triple-expansion engines, 166–7; quadruple-expansion engines, 178; turbine engines, 184; beam engines of American river boats, 262; applied to yachts, 268
Steel, first ship of, 150; development of, 156; advantage of, 157
Steeple engines, 269
Steering gear, steam, of *Great Eastern*, 143; principle of, 144
Steering-wheel, development of, 89
Stella, the, 228
Stephenson, George, 221
Stern, height of, 153, 172, 201
Stern-wheel boats, invention by Robert Stevens of, 63: 258
Stettin Vulcan Co., 174
Stevens, John, stern-wheel steamer of, 63; proposal from Fulton to, 64; the *Phœnix*, 76, 118
Stevens, Robert, invention of tubular boilers by: first screw-steamer of, 63
Stone-Lloyd water-tight doors, 191
Strain, 98, 99, 126; minimised by length, 139; effect of iron and wood in, 146–7

Submarine signalling, 172; on Great Eastern boats, 229; methods of, 305
Subsidy, Cunard Co.'s first, 106; Royal Mail Steam Packet Co.'s first, 112; reduction of, 113; for *Mauretania* and *Lusitania*, 198
"Suction" dredger, 239, 240
Suevic, the, 295
Suez Canal, 115, 116, 117; limitations imposed by, 215
"Sun-and-planet" gear, 37, 47
Sunbeam, the, 270
Sutcliffe, Mrs., on Fulton, 50, 61
Swan, Hunter and Wigham Richardson, 212
Symington, William, engine for Miller's boat by, 43; the *Charlotte Dundas*, 46

Talbot, the, 221
Taylor, James, 42
Taylor, Naval Constructor D. W., experiments in resistance by, 67
Telegraph ships, 242–3
Telephone, use of on *Balmoral Castle*, 219; installation on liners of, 305
Teutonic, the, 168, 179
Teviot, the, 110
Thames, first steamship on the, 83
Thames, the, 84, 111
Thompson, George, & Co., 216
"Three-island" type, 283
Titanic, the, 207, 211, 289
Tonnage, of "turret-ships," 247; measurements of, 312; Royal Commission on, 313; anomalies of, 313–4
"Tonnage-deck," 312
Tonquin, the (ex *City of Paris*), 149
"Topgallant" forecastle, 284
Torricelli, Evangelista, discovery of weight of atmosphere, 20
Towing, feats of, 236–7
Train-ferries, 251
Tramp steamer, the, 250
Trawlers, steam, 252
Trent, the, Slidell and Mason incident, 113
Triad, the, 270, 278, 279
Trial trip, how carried out, 292, 293
Triple-expansion engines, principle of, 117, 166
"Trunk-deck" steamer, 248
Tubular boiler, 133
Tugs, variety of, 234; "Cock" type, 235; Dutch, 236; salvage, 237; New York Harbour, 237; as passenger tenders, 238; paddle-wheel, 239; as trawlers, 252
Turbine, Giovanni Branca and, 20; importance of, 183; invention of, 184; Parsons system of, 186; the *Carmania's*, 187; faults of, 188; the *Vespasian* experiment, 189; of *Virginian* and *Victorian*, 190; of *Carmania*, 192; of *Mauretania* and *Lusitania*, 197, 201; low-pressure of *Laurentic*, 210; on cross-channel boats, 226; on Great Eastern Railway Co.'s boats, 230; on Isle of Man boats, 230; reliability of, 230; on yachts, 274
Turbinia, the, 187
Turret-ships, 245; comparison with "whale-back," 265
Turtle decks of *Oceanic*, 153; of *Umbria*, 158; of *Victoria*, 163; of *Majestic*, 168
Twain, Mark, on Mississippi steamers, 259, 260
Twin-screw, evolution of, 163; introduction of "overlapping," 169; of the *Kaiser Wilhelm der Grosse*, 175; of *Adriatic*, 207; influence of on steering capacity, 318
Twin-ships, 225
Types of steamships, 283–7

Umbria, the, 158–9, 161, 162, 163, 165, 212

Union-Castle Line, 216; ships of, 219
Union Line, 216

Vanadis, the, 280
Ventilation, methods of, 327
Veranda café of *Lusitania*, 301
Vertical trunk engine, 134
Vespasian, the, 189
Victoria, the, 131
Victoria, the (P. & O.), 163
Victoria and Albert, the, 277
Victorian, the, 190
Vigilant, the, 241
Virginian, the, 190, 191
Vulcan Yards, Hamburg, 212

Waesland (ex *Russia*), 150
Wahiva, the, 280–1
Waratah, the, 182
Water-ballast, tanks of cantilever-framed ships, 249; for yachts, 274; tanks for, 315
Water-tight doors of *Oceanic*, 153; Stone-Lloyd system, 191
Watson, G. L., 270
Watt, James, 33; early engine of, 34; association with Boulton, 35; beam engine, 36; "sun-and-planet" gear, 37; rotary engine, 37; invention of fly-wheel, 38; "horse-power" calculations of, 39; anecdote of, 82; invention of condenser, 135, 136
Watt, James, & Co., 140
Watt, James, Junr., and steam-ships, 84
Wave-line theory, 131, 133
Waves, action of, 98
"Well-deck" type, 284–5
West Indies, inauguration of mail service to, 110
Weymouth and Channel Islands Steam Packet Co., 228
"Whale-back" steamer, 265
White, Sir William H., 197, 203
White Star Line, first steamships of, 151; Atlantic competition, 151–5, 168; "intermediate" ships of, 178; recent ships, 193–4; 206–7, 209, 211; sailing ships of, 215; freight and live-stock steamers, 219
Wigram and Green, 93
William Facwett, the, 114
Williams and Guion, 155, 212
Williamson, Capt. J.: "The Clyde Passenger Steamer: Its Rise and Progress during the Nineteenth Century," 78
Williamson's "Memorials of James Watt," 83
Wilson, Thomas, & Sons, 216
Wireless telegraphy on *Campania* and *Lucania*, 171; on P. & O. ships, 218; on cross-channel boats, 226; usefulness of, 229; on yachts, 271; on liners, 306; instances of utility of, 307–8
Wittekind, the, 295
Wood, John, & Co., and the *Comet*, 78
Worcester, Marquis of, 9, 10, 18, 20

Yacht, the steam, Royal Yacht Squadron and, 266–8; Northern Yacht Club and, 267; Robert Napier and, 267; development of, 269; the *Sunbeam*, 270; lines of, 270; decks of, 272; fittings of, 273; engines and ballast, 274; Royal, 277–8; the *Sagitta*, 278; the *Triad*, 278–9; noted yachts, 280–1
Ymuiden Tug Company, 237

Zwarte Zee, the, 236

PRINTED BY CASSELL & COMPANY, LIMITED, LA BELLE SAUVAGE, LONDON, E.C.